AL.2.1987-489

Water Resources

WILLOW CREEK BASIN

HYDROLOGIC ASSESSMENT OF RESERVOIR ALTERNATIVE

Alberta
ENVIRONMENT

DDN 7292325

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Hydrology Branch
Technical Services Division
Water Resources Management Services
Alberta Environment

WILLOW CREEK BASIN

HYDROLOGIC ASSESSMENT OF RESERVOIR ALTERNATIVES

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NOVEMBER 1985

1. BACKGROUND

Regional planning studies completed in the mid-seventies indicated that, with the present growth rate of water demands in the Willow Creek Basin, difficulties would be experienced in meeting these demands about the mid-eighties. Detailed studies were therefore recommended to develop a water resource management strategy for the Basin.

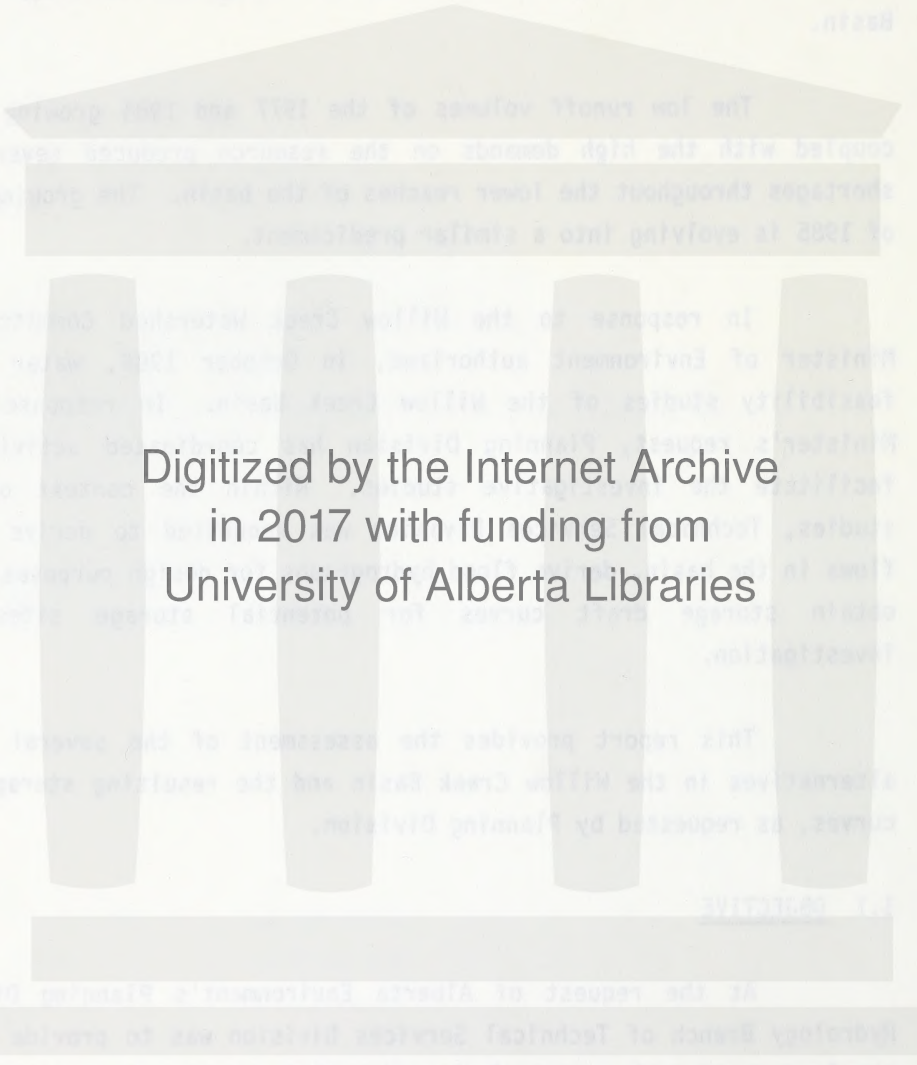
The low runoff volumes of the 1977 and 1984 growing seasons coupled with the high demands on the resource produced severe water shortages throughout the lower reaches of the basin. The growing season of 1985 is evolving into a similar predicament.

In response to the Willow Creek Watershed Committee, the Minister of Environment authorized, in October 1984, water storage feasibility studies of the Willow Creek Basin. In response to the Minister's request, Planning Division has coordinated activities to facilitate the investigative studies. Within the context of these studies, Technical Services Division was requested to derive natural flows in the basin, derive flood hydrographs for design purposes, and to obtain storage draft curves for potential storage sites under investigation.

This report provides the assessment of the several storage alternatives in the Willow Creek Basin and the resulting storage draft curves, as requested by Planning Division.

1.1 OBJECTIVE

At the request of Alberta Environment's Planning Division, Hydrology Branch of Technical Services Division was to provide a water supply assessment for each of the identified storage alternatives, given a set of monthly agricultural demands.



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SYNOPSIS

An hydrologic assessment was performed on four reservoir alternatives in the Willow Creek Basin. The assessment was based on the effects of the reservoirs on the monthly streamflow data of the Willow Creek Basin for the period 1912 to 1983. Three independent options were examined for each alternative. The first option represented those optimum conditions for which agricultural demands were met with 100 percent reliability for the period of record. The second and third options represented those conditions for which 95 percent and 90 percent reliability rates occurred, respectively.

Two computer models were developed to assist in the assessment. The assumptions, procedures, and results of the models are presented and discussed. The overall results, summarized as storage-draft curves, are also included.

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ACKNOWLEDGEMENTS

The support provided by each of the following persons in completing this report is gratefully acknowledged.

V. DaSilva, Technical Services Division - Drafting
S. Figliuzzi, Technical Services Division - Review and Comments
D. Hart, Planning Division - Review and Comments
A. Mustapha, Technical Services Division - Review and Comments
L. Szojka, Planning Division - Review and Comments
S. Ross, Technical Services Division - Manuscript

Specifically, this study includes:

a) the identification of several storage options,
b) the description of use of the generated streamflow data base,
c) the description of reservoir operation procedures, including the development of computer programs, to simulate the effects of each storage option on natural flows,
d) the description of the methodology used in deriving storage-draft curves,
e) the resulting storage-draft curves of each tested storage option, and
f) the interpretation and assessment of results.

2. COMPILATION OF DATA

Prerequisite to the assessment of alternatives was the compilation of data with regards to: (i) the physical characteristics of each alternative, (ii) the generated streamflows of the basin, and (iii) the operation procedures for the reservoirs. Details of these data are described in the following subsections.

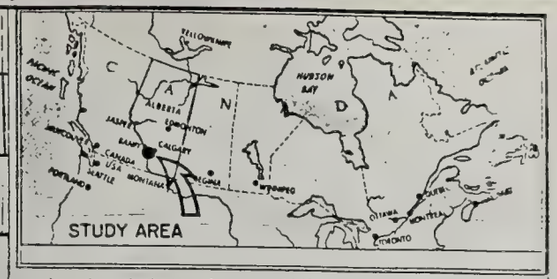
2.1 IDENTIFICATION OF ALTERNATIVES

With the direction of Planning Division and communications with Design and Construction Division, three potential reservoir sites were identified. The three potential reservoir sites, along with existing conditions, form the four water management alternatives analyzed in this report. Table 2.1 provides a summary of the four alternatives. The locations of the reservoir sites are shown in Figure 1.

Alternative A1 involved the assessment of the basin under existing conditions of storage capacity. The results of this alternative provided an indication of the yield for various levels of efficiency which could be obtained if the existing Chain Lakes Reservoir, without additional storage in the basin, were used to meet agricultural demands. The outflows computed for this alternative were not expected to coincide with the respective recorded flows since, historically, the operation of the Chain Lakes Reservoir was on an ad hoc basis, dependent primarily upon downstream municipal demands. The operation of the modelled reservoir for Alternative A1 was based on the assumption of predetermined demands, which were fixed for each year. These demands were quantified by Planning Division and are described in more detail in subsection 3.5 of this report.

Table 2.1: Inventory of Reservoir Alternatives

Alternative	Site #	Name	Description
A1	--	Chain Lakes Reservoir	Chain Lakes Reservoir only
A2a	2	Pine Coulee Offstream Reservoir	Offstream Storage in Pine Coulee, in conjunction with Chain Lakes Reservoir. Diversion Canal Capacity = 300 cfs
A2b	2	Pine Coulee Offstream Reservoir	As A2a; Diversion Canal Capacity = 600 cfs
A2c	2	Pine Coulee Offstream Reservoir	As A2a; Diversion Canal Capacity = 900 cfs
A3	2	Pine Coulee Onstream Reservoir	Onstream Reservoir downstream of Pine Coulee and Willow Creek Confluence in conjunction with Chain Lakes Reservoir
A4	1	Claresholm Reservoir	Onstream Reservoir near Town of Claresholm, in conjunction with Chain Lakes Reservoir



LEGEND:

- MAJOR BASIN
- SUB-BASIN
- ▲ HYDROMETRIC STATION
- = POTENTIAL DAM SITE
- ADDITIONAL CHAIN LAKES RESERVOIR DRAINAGE AREA

SCALE 1:250 000

Miles 5 0 5 10 15 20 Miles

Kilometres 5 0 5 10 15 20 25 30 Kilometres

Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	WILLOW CREEK BASIN LOCATION MAP
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Alternative A2 involved both the Chain Lakes Reservoir and the Pine Coulee Offstream Reservoir (also referred to as Site #2). In this alternative, Chain Lakes Reservoir was required to supply a base flow during the winter months only, while the reservoir in Pine Coulee was required to supply all other flow requirements throughout the year. Since local runoff from Pine Coulee is relatively insignificant, the reservoir storage would be supplemented by means of a canal which diverts excess flows from Willow Creek to Pine Coulee. In this regard, three canal capacities were assessed. Alternative A2a included a diversion capacity of 300 cubic feet per second (cfs); Alternative A2b included a diversion capacity of 600 cfs; Alternative A2c included a diversion capacity of 900 cfs.

Alternative A3 involved Chain Lakes Reservoir and the Pine Coulee Onstream Reservoir (also referred to as Site #2). As in Alternative A2, Chain Lakes Reservoir was required to supply a winter base flow, while the Pine Coulee Onstream Reservoir was required to supply all other flow requirements throughout the year.

Alternative A4 involved Chain Lakes Reservoir and the Claresholm Reservoir (also referred to as Site #1). As in Alternative A2, the Chain Lakes Reservoir was required to supply a winter base flow, while the onstream Claresholm Reservoir was required to supply all other flow requirements throughout the year.

2.2 PHYSICAL CHARACTERISTICS OF THE RESERVOIRS

At the present time, a single reservoir exists in the Willow Creek Basin, that being the Chain Lakes Reservoir. Four additional sites for reservoirs have been identified elsewhere in the basin, and are shown in Figure 1. At the present time, detailed surveys and topographical maps had been finalized for three of the sites, namely Alternatives A2 (Site #2), A3 (Site #2b) and A4 (Site #1). Without the detailed surveys and topographical maps for the fourth site (Site #3), a hydrologic assessment of that site would necessarily be less definitive than the other alternatives and therefore could prove difficult for comparative purposes. Therefore Site #3 was not assessed at this time.

Elevation-area-capacity relationships of each reservoir were produced by Hydrology Branch, using 1:2000 topographical maps having 2.5 meter contour intervals provided by Survey Branch of Technical Services Division. Maximum potential storage levels due to topographic limitations, Permanent Pool Storage and diversion canal capacities, were obtained from Design and Construction Division. A summary of the physical characteristics of the existing and proposed reservoirs used in the assessments are presented in Table 2.2. Area capacity curves of the four reservoirs are presented in Figure 2 through 5.

2.3 TESTED OPTIONS

The water management alternatives identified in Section 2.1 were evaluated at various levels of storage up to the topographical Maximum Potential Storage Level, MPSL, (of each of the proposed reservoirs), in order to determine the reservoir yield to storage volume ratio. The reservoir yield, in excess of winter base flow (which in all alternatives was supplied by the existing Chain Lakes Reservoir), was assessed for three storage options of acceptable reliability. The three tested options of acceptable reliability were the 100%, 95%, and 90%. The 100% option represented the condition for which there were no failures in meeting the May through October monthly demand for the 72 years of record. The 95% option represented the condition for which successes in meeting the monthly demand occurred in all months for 95% of the May through October 72 years of record. The 90% option represented the condition for which successes in meeting the May through October monthly demand occurred in all months for 90% of the 72 years of record. A success was defined as a resultant flow which was at least 90% of the demand flow for each month of the year. A failure was defined as a resultant flow which was less than 90% of the demand flow for at least one month in the year. A summary of the tested options is presented in Table 2.3. A graphical description of these terms is provided in Figure 6.

Table 2.2: Physical Characteristics of Reservoirs

Reservoir	G.S.C. Elevation Feet	Surface Area Acres	Reservoir Capacity Acre-Feet	Source of Information*	Other*
Chain Lakes	4222.5	0	0	W.E.R.	
	4234.5	320	1200		Permanent Pool
	4238.0	430	2200		Storage = 1200 ac.ft.
	4241.0	540	3400		(W.E.R.)
	4245.0	620	5400		F.S.L. = 4255.5 ft.
	4248.0	670	7400		(W.E.R.)
	4251.0	720	9640		
	4255.5	770	13000		
Pine Coulee Offstream	3390.0	0	0	HYD.	
	3395.6	77	318		Permanent Pool
	3403.8	250	1661		Storage = 11000 ac.ft.
	3412.0	360	4165		(D.&C.)
	3420.2	501	7698		M.P.S.L. = 3453.1 ft.
	3428.4	711	12669		(D.&C.)
	3436.6	911	19320		Diversion Canal
	3444.8	1189	27931		Capacity Ranging
	3453.1	1386	38490		From 300 cfs to
	3461.2	1596	51719		900 cfs (HYD.)
Pine Coulee Onstream	3379.3	0	0	HYD.	
	3387.5	33	137		Permanent Pool
	3395.7	180	1011		Storage = 11000 ac.ft.
	3403.9	382	3315		(D.&C.)
	3412.1	528	7018		M.P.S.L. = 3453.1
	3420.3	727	12197		(D.&C.)
	3428.5	1018	19356		
	3436.7	1305	28882		
	3444.9	1708	41237		
	3453.1	2091	56818		
	3461.3	2485	75588		
Claresholm	3308.7	0	0	HYD.	
	3313.6	13	50		Permanent Pool
	3321.9	105	483		Storage = 5000 ac.ft.
	3330.1	229	1852		(D.&C.)
	3338.3	391	4393		M.P.S.L. = 3379.3
	3346.5	501	8051		(D.&.C.)
	3354.7	573	12459		
	3362.9	712	17734		
	3371.1	832	24070		
	3379.3	1036	31731		

* D. & C. = Design and Construction Division, Alberta Environment
HYD. = Hydrology Branch, Technical Services Division, Alberta Environment
W.E.R. = Reference 4
F.S.L. = Full Supply Level
M.P.S.L. = Maximum Potential Storage Level

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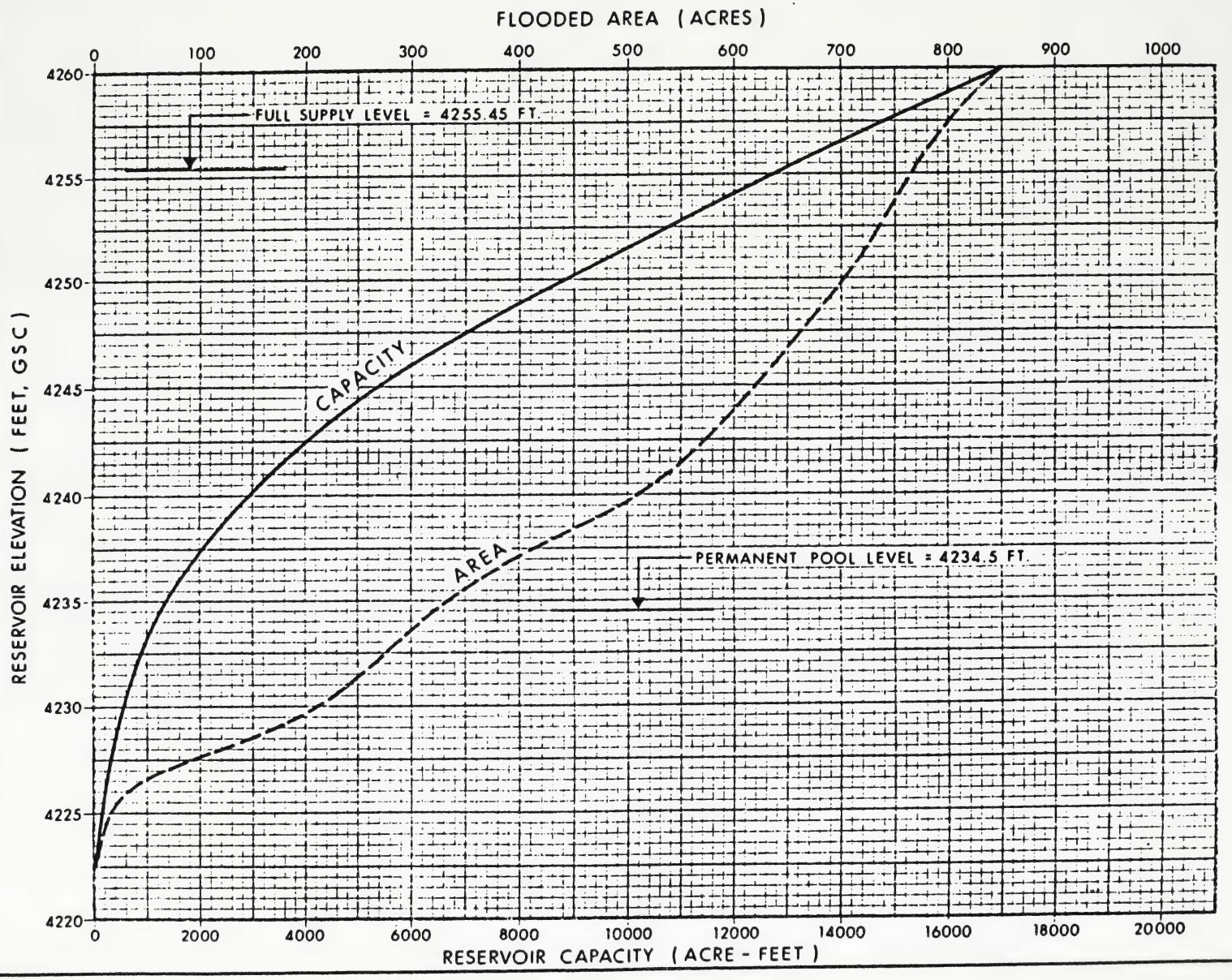

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AREA CAPACITY CURVES

ALTERNATIVE A1: CHAIN LAKES RESERVOIR

FIGURE No. 2

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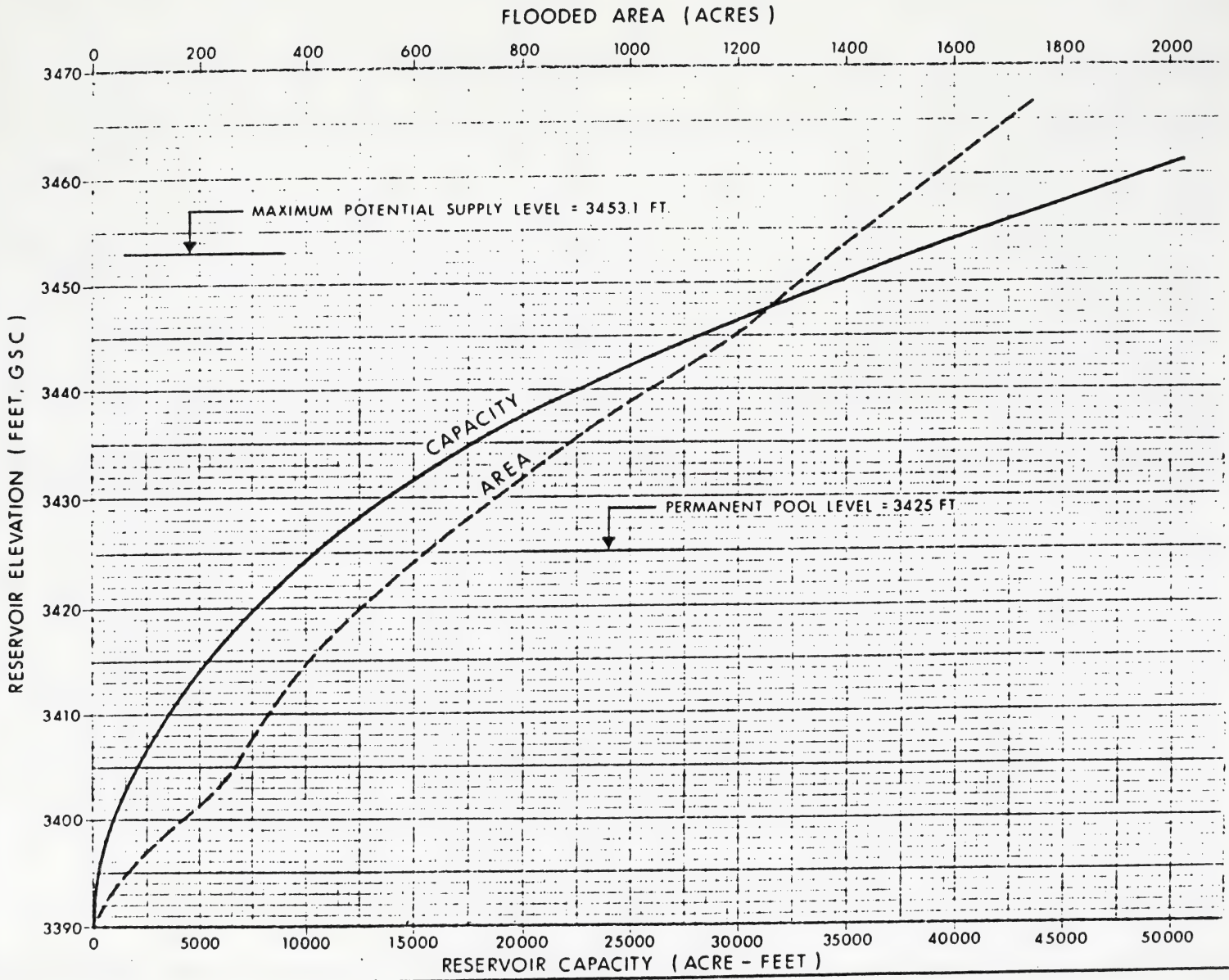

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AREA CAPACITY CURVES

ALTERNATIVE A2 : PINE COULEE

OFFSTREAM RESERVOIR

FIGURE No. 3

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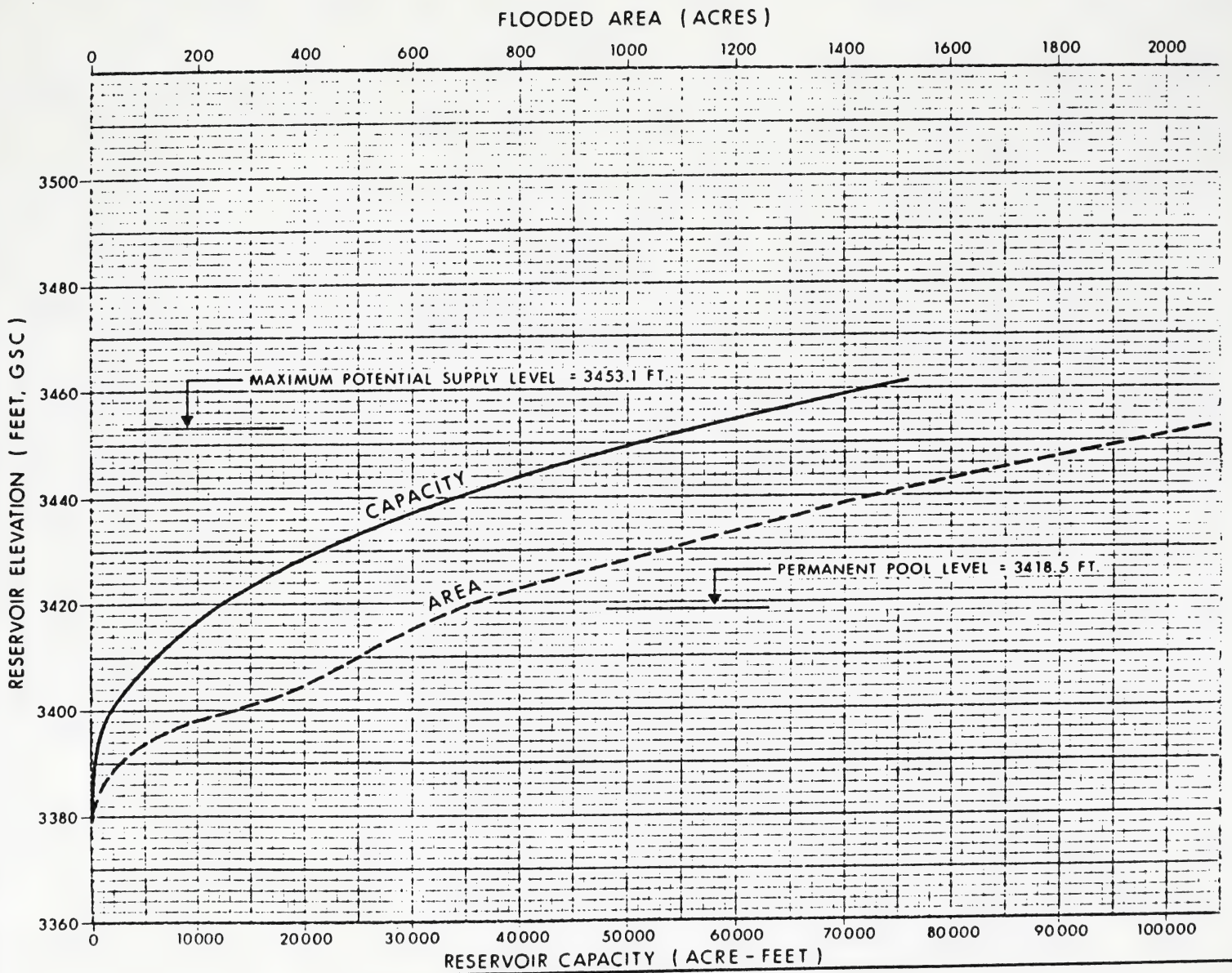

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AREA CAPACITY CURVES
ALTERNATIVE A3 : PINE COULEE
ONSTREAM RESERVOIR

FIGURE No. 4

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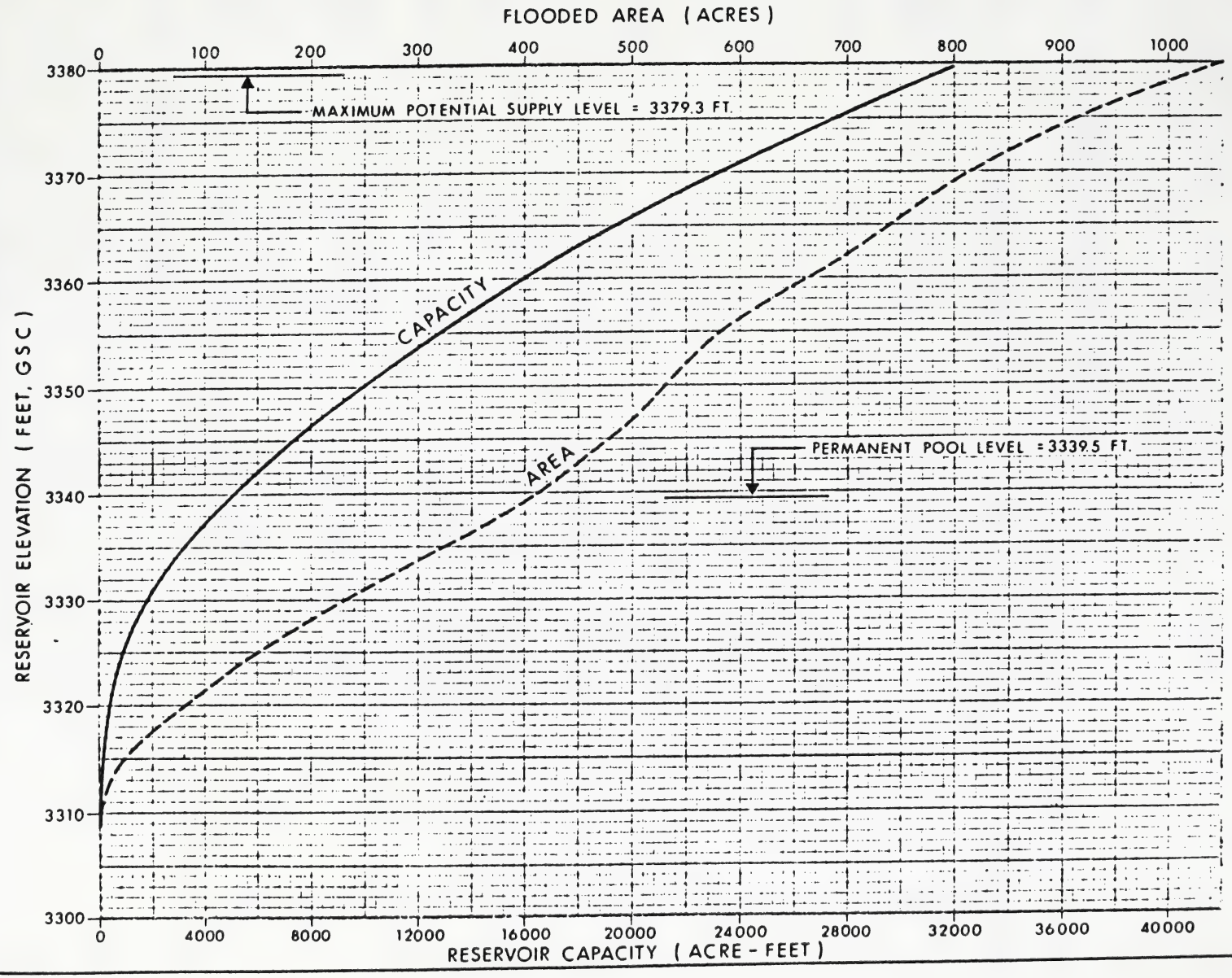

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AREA CAPACITY CURVES

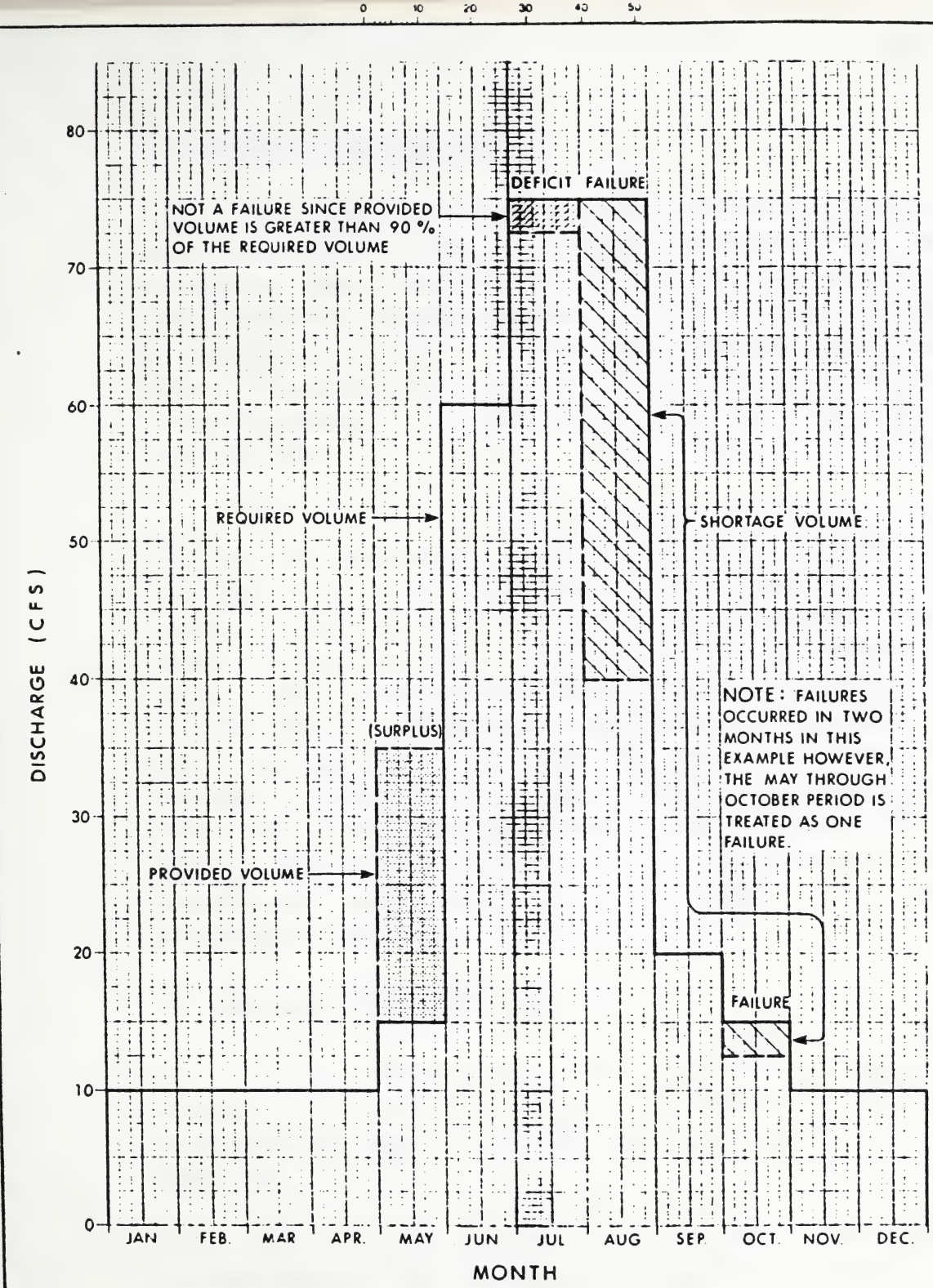
ALTERNATIVE A4 : CLARESHOLM RESERVOIR

FIGURE No. 5

Table 2.3: Summary of Tested Options

Option Code	Description: Reservoir Supplying Winter Base Flow	Description: Reservoir Supplying May through October Demand	Reliability %
100-A1	Chain Lakes	Chain Lakes	100
95-A1	Chain Lakes	Chain Lakes	95
90-A1	Chain Lakes	Chain Lakes	90
100-A2a	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 300 cfs	100
95-A2a	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 300 cfs	95
90-A2a	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 300 cfs	90
100-A2b	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 600 cfs	100
95-A2b	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 600 cfs	95
90-A2b	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 600 cfs	90
100-A2c	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 900 cfs	100
95-A2c	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 900 cfs	95
90-A2c	Chain Lakes	Pine Coulee Offstream, DIVCAP* = 900 cfs	90
100-A3	Chain Lakes	Pine Coulee Onstream	100
95-A3	Chain Lakes	Pine Coulee Onstream	95
90-A3	Chain Lakes	Pine Coulee Onstream	90
100-A4	Chain Lakes	Claresholm	100
95-A4	Chain Lakes	Claresholm	95
90-A4	Chain Lakes	Claresholm	90

*DIVCAP - Diversion Canal Capacity



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	GRAPHICAL DESCRIPTION OF TERMS
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2.4 HISTORICAL STREAMFLOW DATA

The capability of each alternative in supplying downstream demands was assessed using an historical period of monthly mean streamflows. Complete data sets of natural flows for the period 1912 to 1983 were produced for eleven subbasins in the Willow Creek Basin and are presented in the report by FIGLIUZZI (1985). However, the data sets could not be used as presented due to the difference in the assessed and historical operations of the Chain Lakes Reservoir and its influence on downstream flows.

The original data sets were therefore manipulated to represent the local flows contributed by each sub-basin. These data sets were determined by subtracting the streamflows of an upstream station from those of a downstream station. Numerous negative inflows resulted, although of small magnitude. No effort was made to eliminate the negative flows. A second modification entailed the inclusion of inflow due to the additional drainage area located immediately northwest of the Chain Lakes Reservoir. Inflows from the additional 27 km^2 were estimated by multiplying the flows of streamflow gauging station C5AB039, Willow Creek below Lane Creek (as presented in the report by FIGLIUZZI (1985)), by the drainage area ratio of the two basins: 27 km^2/730 km^2 = .037. The pertinent data sets used in the assessment are presented in Appendix A.

2.5 OPERATIONAL PROCEDURES OF RESERVOIRS

As there exists a limited supply of streamflow, an operational procedure for the use of the resource was necessary. A priority sequence was developed to accommodate the decision making process of water usage.

For offstream storage alternatives (i.e., Pine Coulee Offstream Reservoir) the following priority sequence was adopted.

For a given monthly volume:

1. Allow flow in Willow Creek to meet downstream demands; if streamflow volume is insufficient, release from reservoir, if possible.
2. If flow volume is in excess of downstream demands, the excess volume (to a maximum of the diversion capacity) is diverted to the reservoir to attempt to fill the reservoir to F.S.L. if not already at that level.
3. Any flow volume in excess of downstream demands and diversion capacity is lost downstream, unused.

For onstream storage alternatives (i.e., Chain Lakes, Pine Coulee Onstream, Claresholm Reservoirs), the following priority sequence was adopted.

For a given monthly inflow volume:

1. The total of the streamflow volume enters the reservoir.
2. If reservoir F.S.L. is exceeded, release excess water to meet F.S.L..
3. If downstream demands are not met with the excess water, release from reservoir, if possible.

3. WATER BALANCE SIMULATION

The repetitive nature of assessing a development alternative for each month of a 72 year period is ideally suited towards computer assisted analysis. A computer model was developed to simulate the effects of each type of reservoir: one for onstream storage; one for offstream storage. The effects of a proposed development option on pre-development flows were simulated purely on an accounting basis during discrete time intervals. Channel routing was not considered, implying that channel storage occurred neither during the month nor from one month to the next. On a monthly basis, this assumption does not bias the results in favor of any particular option. The listing of each model is provided in Appendix B.

One who is familiar with FORTRAN computer programming would be able to follow the logistics of the models. However, the implied assumptions are not immediately recognizable and are therefore stated explicitly below.

3.1 LOCAL INFLOWS

Data sets of local inflows used in the analysis are presented in Appendix A. Details of the production and modification to those data sets are outlined in Section 2.4 of this report.

3.2 OCCURRENCE OF ICE

Two types of ice formation were identified in this study: channel ice and reservoir ice.

The occurrence of ice in the river channel was accounted for implicitly via the streamflow data sets. Experience has shown that winter releases of 10 to 15 cfs from the Chain Lakes Reservoir result in streamflows of 3 to 5 cfs near Claresholm and are reflected in the data sets. A large percentage of these streamflow losses were due to the formation of channel ice. Identical losses due to ice formation were

assumed to have occurred for each scenario, therefore no adjustments were made to the data sets to account for the occurrence of ice formation in channels.

The occurrence of additional dead storage due to ice formation in reservoirs was treated separately. Ice thickness data collected from the Chain Lakes Reservoir were examined and a simplified schedule of ice thickness on reservoirs was used. It was assumed that: in November, 0.5 feet of ice thickness existed; December: 1.0 foot; January: 1.5 feet; February: 2.0 feet; March: 1.0 foot; April through October: no ice existed. The storage volume lost to ice formation in a particular month was calculated by multiplying the assumed ice thickness, in feet, by the surface area of the reservoir at the beginning of the month, in acres, yielding an ice volume, in acre-feet.

3.3 EVAPORATION AND PRECIPITATION

Since a new water body is introduced to the Willow Creek Basin in each development scenario, the effects of evaporation and precipitation on reservoir storage supplies are not reflected in the streamflow data sets. To account for the accumulation of precipitation in the reservoir, the monthly precipitation data set of Claresholm was used (from CARD (1982), Appendix 2). To account for the water deficit caused by evaporation, the completed monthly evaporation data set of Calgary was used (from CARD (1982), Appendix 3). An adjustment to the magnitude of the evaporation values was made, in accordance with Figure 2 of CARD (1982), Appendix 3, to accommodate for the difference in latitude and elevation between Calgary and each of the reservoir sites. Although no adjustment was made for the Chain Lakes Reservoir, the evaporation data set for each of the proposed reservoirs was obtained by increasing the Calgary data set by a factor of 1.025. The precipitation and evaporation data sets were summed to produce the net evaporation data set. The volume of water represented by the net evaporation was calculated by multiplying the net evaporation, in feet, by the surface area of the reservoir at the beginning of the month, in acres, to produce a net evaporation volume, in acre-feet.

During the winter season, precipitation normally falls as snow and evaporation is relatively small. In each model, the net evaporation for November through March was accumulated and then released in April.

3.4 SEEPAGE LOSSES

Seepage losses along Willow Creek were assumed to be identical for each scenario and therefore reflected in the produced streamflow data sets. No adjustments were made to the data sets to account for any possible changes in seepage losses.

Seepage losses in reservoirs were assumed to be negligible. During initial filling of a reservoir, losses due to seepage may in fact be significant although it is expected that seepage losses would be negligible in the long term.

3.5 DOWNSTREAM FLOW REQUIREMENTS

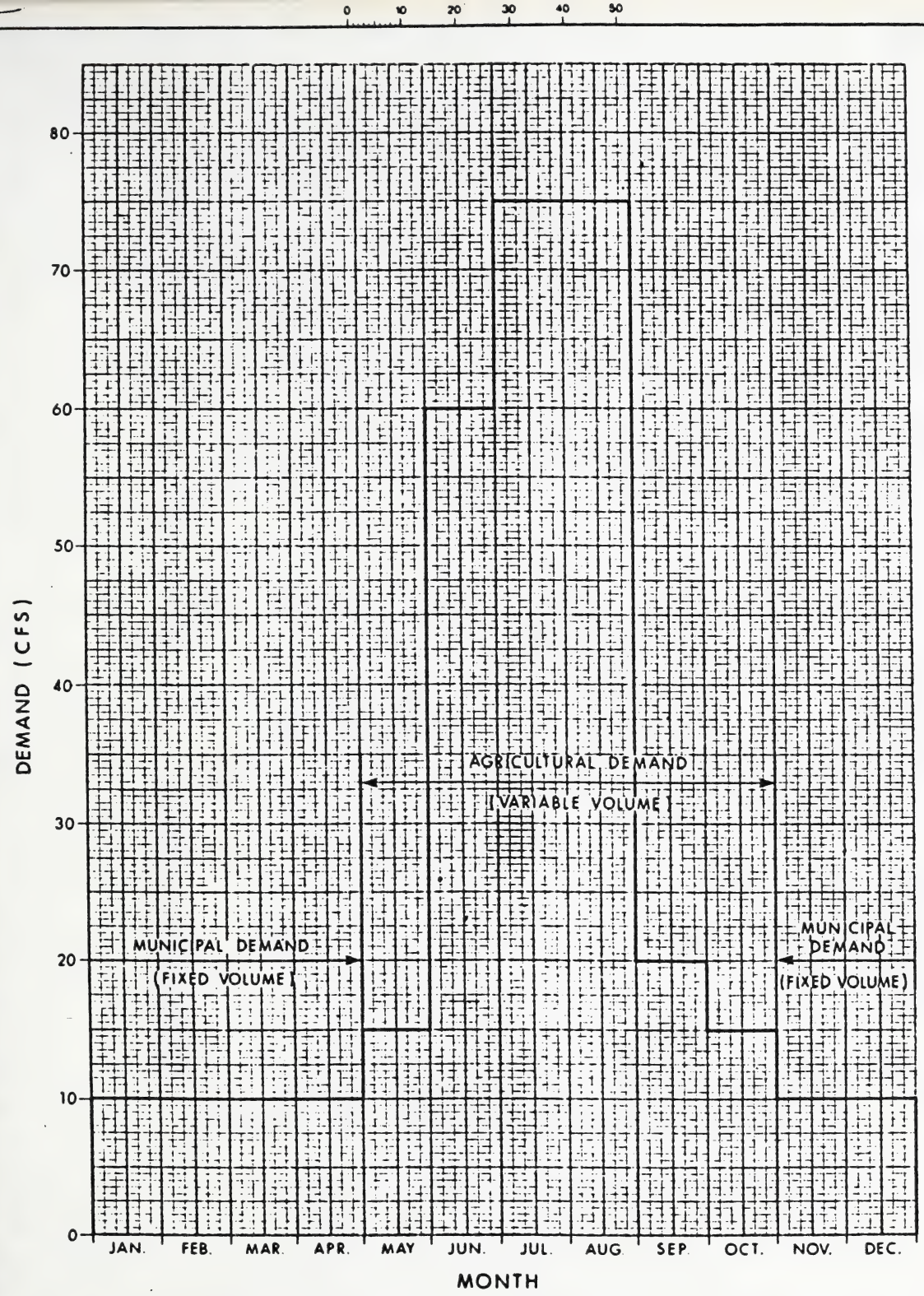
To assist in the assessment of alternative development options, monthly flow requirements downstream of the reservoir sites were estimated by Planning Division. A summary of the monthly requirements are presented in Table 3.1. The distribution of monthly demands in the Willow Creek Basin is presented graphically in Figure 7.

In this study, each option was assessed using two sets of demands: a set of fixed demands which were to be met by the Chain Lakes Reservoir, and a set of variable demands which were to be met by a downstream reservoir.

The fixed demands consisted of a constant 10 cfs from November through April, emanating from the south end of Chain Lakes Reservoir into Willow Creek and a constant 3 cfs throughout the year emanating from the north end of Chain Lakes Reservoir into Stimson Creek (outside Willow Creek Basin).

Table 3.1: Summary of Downstream Flow Requirements

	Estimated Present Conditions		Proposed Requirements		
	Chain Lakes Demand		Chain Lakes Reservoir Demand		Downstream Reservoir Demand
Month	Stimson Creek cfs	Willow Creek cfs	Stimson Creek cfs	Willow Creek cfs	cfs
Jan.	3	15	3	10	--
Feb.	3	15	3	10	--
Mar.	3	10	3	10	--
Apr.	3	10	3	10	--
May	3	5	3	--	15
June	3	5	3	--	60
July	3	5	3	--	75
Aug.	3	10	3	--	75
Sept.	3	10	3	--	20
Oct.	3	10	3	--	15
Nov.	3	15	3	10	--
Dec.	3	15	3	10	--



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION **HYDROLOGY BRANCH**	MONTHLY DEMAND DISTRIBUTION IN THE WILLOW CREEK BASIN
SUBMITTED S. FIGLIUZZI, P. ENG. DATE NOV., 1985	DESIGNED P. STEVENS, P. ENG CHECKED	
APPROVED M. MUSTAPHA, P. ENG. DATE NOV., 1985	DRAWN V. DA SILVA CHECKED P. STEVENS, P. ENG.	SCALE AS SHOWN DATE NOV., 1985 — **FIGURE No. 7**

FILE No

The variable demands were derived from the downstream reservoir demands presented in Table 3.1. The relative size of these demands (from May through October) remained fixed. However, the magnitude of the total demand was varied so as to obtain a failure rate approximating that of the scenario being investigated. For example, to determine the reliability of a reservoir having a May to October demand of 20,000 acre-feet, the demand was distributed on a monthly basis by multiplying the 20,000 acre-feet by each of the factors shown in the last column of Table 3.2 to arrive at the flow in cfs for each month. These numbers were input in the appropriate computer model to ascertain the reliability of the reservoir at the 20,000 acre-feet level of demand.

Table 3.2: Modelled Streamflow Demands

Month	Demand Requirements		
	Fixed (from Chain Lakes)		Variable*
	North End to Stimson Creek (cfs)	South End to Willow Creek (cfs)	(for A Downstream Reservoir)
Jan.	3	10	
Feb.	3	10	
Mar.	3	10	
Apr.	3	10	
May	3		0.000948
Jun.	3		0.003790
Jul.	3		0.004739
Aug.	3		0.004739
Sep.	3		0.001261
Oct.	3		0.000948
Nov.	3	10	
Dec.	3	10	

* Multiply the May to October variable demand, in acre-feet, by each of the factors shown to obtain the monthly demand, in cfs.

3.6 PINE COULEE OFFSTREAM DIVERSION CANAL

Alternative A2 (Pine Coulee Offstream Reservoir) includes a canal which diverts streamflow from Willow Creek to the Pine Coulee Offstream Reservoir during the April through October period. Since the cost of the diversion canal was very sensitive to the capacity of the canal, a more detailed analysis of streamflow through the canal was required. A monthly time step did not adequately assess the effect of streamflow variability on the efficiency of the canal to divert the required volumes of water to the reservoirs. Considering that (a) much of the monthly streamflow data were generated through regression analysis and (b) (to a lesser extent) the cost of computer runs, the time step used to assess the diversion canal capacity was limited to five day intervals.

The magnitude of the five-day streamflow volumes were determined thus:

1. Each month was separated into six intervals: five 5-day intervals and the sixth interval ranged from three to six days, contingent upon the month.

2. Daily recorded data were averaged for each of the six intervals per month, for the period 1912 to 1983. Since no streamflow gauging station in the Willow Creek Basin existed for the entire period, several stations were utilized in attaining the five-day averages and are presented in Appendix C.

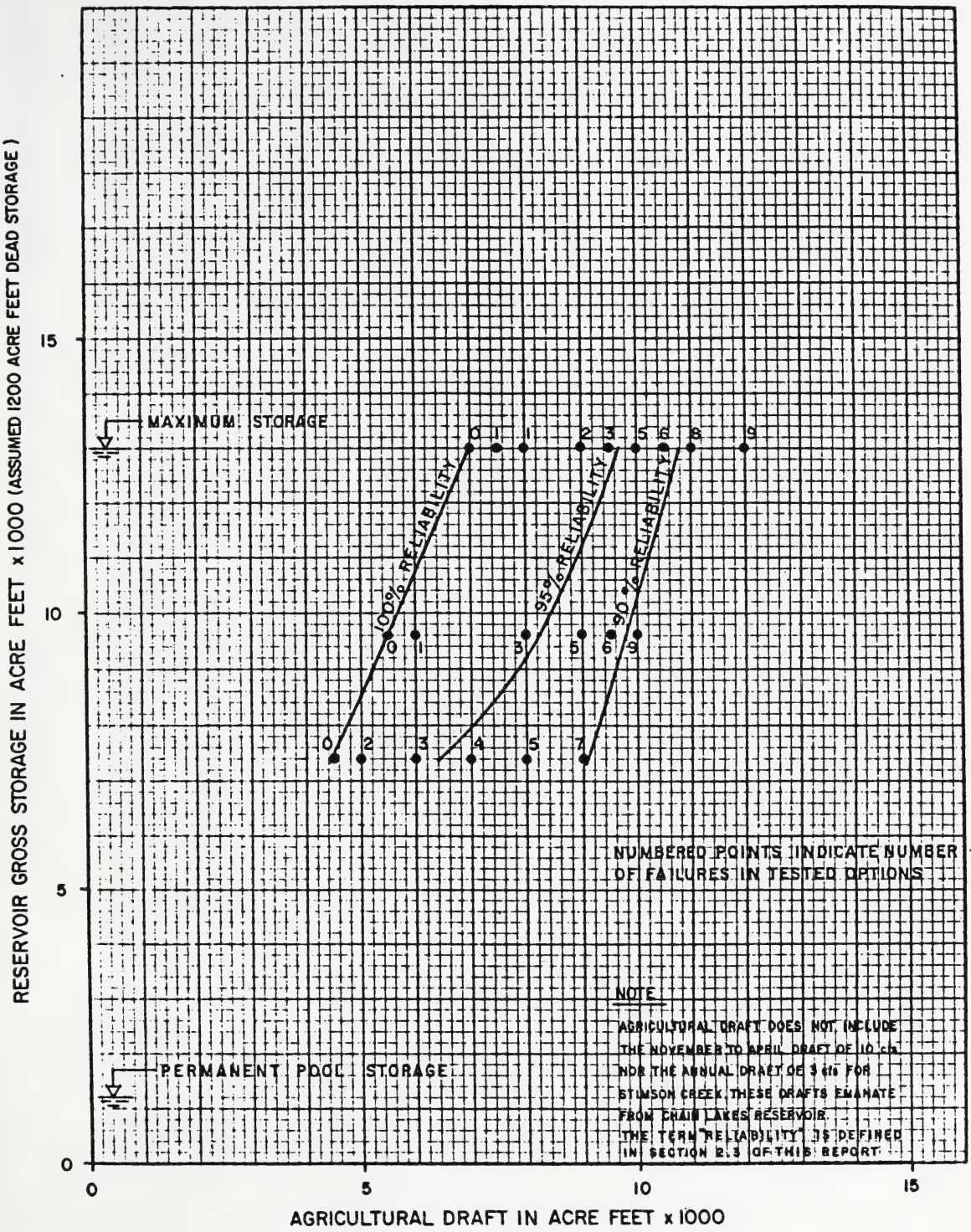
3. The monthly inflow available to the diversion canal was then distributed using the appropriate volumetric ratios.

4. RESULTS

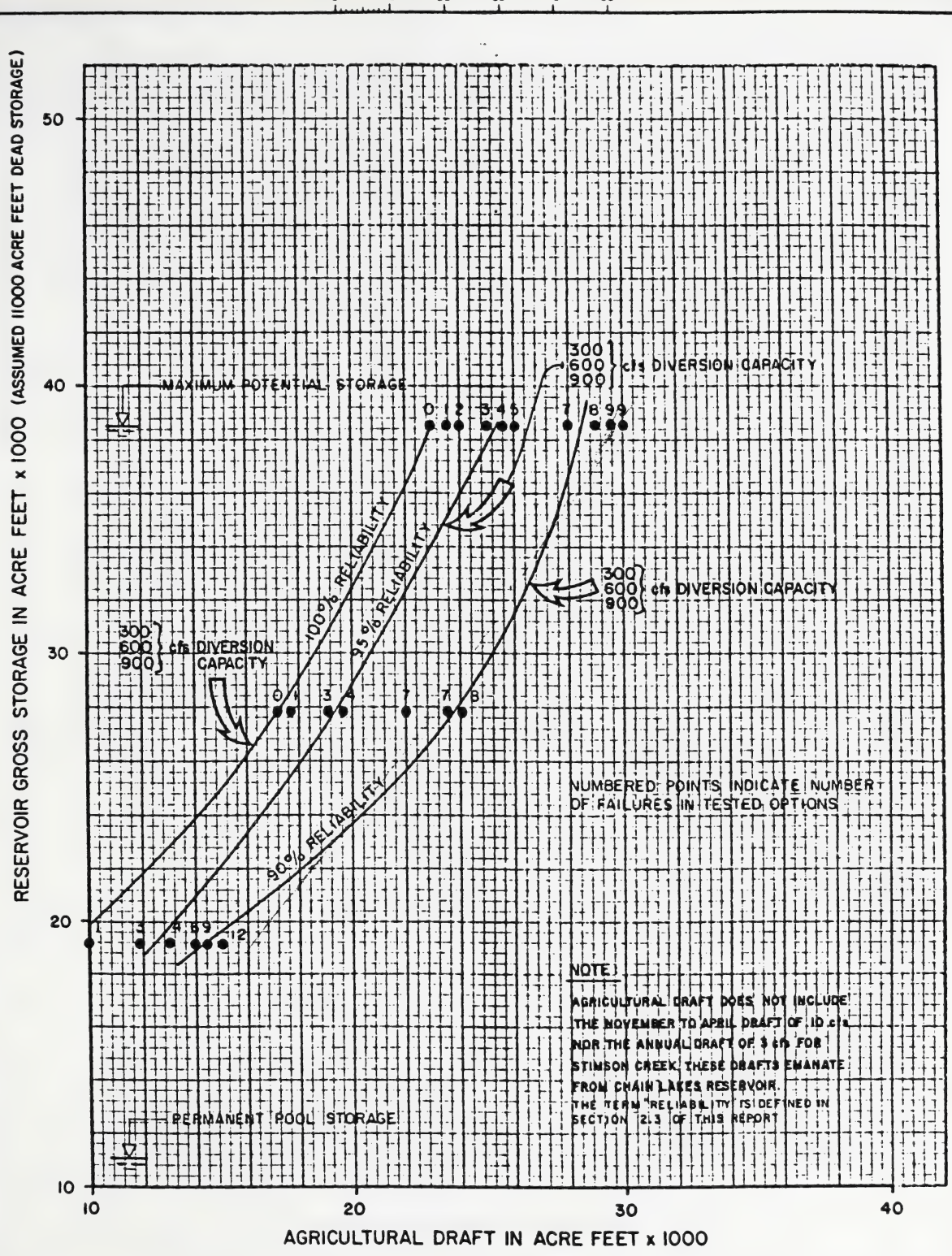
The detailed output of each option is about 1000 lines long. Such an amount of output was considered too voluminous to be included in this report and would serve a limited usefulness. The detailed output was retained on file in Hydrology Branch.

Storage draft curves for each of the alternatives were developed for options having 100, 95, and 90% reliabilities. The results for alternatives A1, A2, A3, and A4 are presented in Figures 8, 9, 10, and 11, respectively. As outlined in Section 2.3 a success in meeting the annual agricultural demand was considered to have occurred if the provided flow was at least 90% of the demand flow in all months during the May to October period of operation.

Detailed summaries, in terms of number of failures which would have occurred for each month and reservoir yield, for simulation runs which approximated the 100, 95, and 90% reliabilities at the topographical maximum storage level for each of the alternatives are presented in Table 4.1. Failures in winter months for alternatives A3 and A4 as indicated in Table 4.1 are not the results of Chain Lakes being unable to meet the winter flow requirements but rather are the combined result of both the downstream reservoir having been drawn down to the permanent pool level and production of surface ice on the reservoir. Table 4.2 provides further detail, in terms of both duration and severity of failures for the 100, 95, and 90% reliabilities at the topographical maximum storage level for each alternative. Table 4.2 may be read as follows; for option 95-A2a (that is, the Pine Coulee Offstream Reservoir, with a diversion canal capacity of 300 cfs and an acceptable reliability of 95% for the period of record), the system would have succeeded in supplying a firm yield of 25,500 acre-feet for about 95% of the years. More specifically, four years resulted in failures (1931, 1936, 1937 and 1944), the 1931 failure persisted for one month in October with the May through October shortage being 362 acre-ft or 2.2% of the annual draft. Table 4.3 provides further information in regards to duration and severity of failure to meet winter demand for the maximum development options and can be read in a similar fashion as Table 4.2.


RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 1200 ACRE FEET DEAD STORAGE)
AGRICULTURAL DRAFT IN ACRE FEET x 1000
MAXIMUM STORAGE
PERMANENT POOL STORAGE
100% RELIABILITY
95% RELIABILITY
90% RELIABILITY
NUMBERED POINTS INDICATE NUMBER OF FAILURES IN TESTED OPTIONS
NOTE
AGRICULTURAL DRAFT DOES NOT INCLUDE THE NOVEMBER TO APRIL DRAFT OF 10 cfs NOR THE ANNUAL DRAFT OF 3 cfs FOR STIMSON CREEK. THESE DRAFTS EMANATE FROM CHAIN LAKES RESERVOIR.
THE TERM "RELIABILITY" IS DEFINED IN SECTION 2.3 OF THIS REPORT.

Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	STORAGE DRAFT CURVES ALTERNATIVE A1 : CHAIN LAKES RESERVOIR
SUBMITTED B.J. FIGLIUZZI P. ENG. DATE	DESIGNED P. STEVENS P.ENG. CHECKED	
APPROVED A.M. MUSTAPHA P.ENG DATE	DRAWN I. LUKNAR CHECKED P. STEVENS P. ENG.	SCALE AS SHOWN DATE SEPT. 1985 — FIGURE No. 8

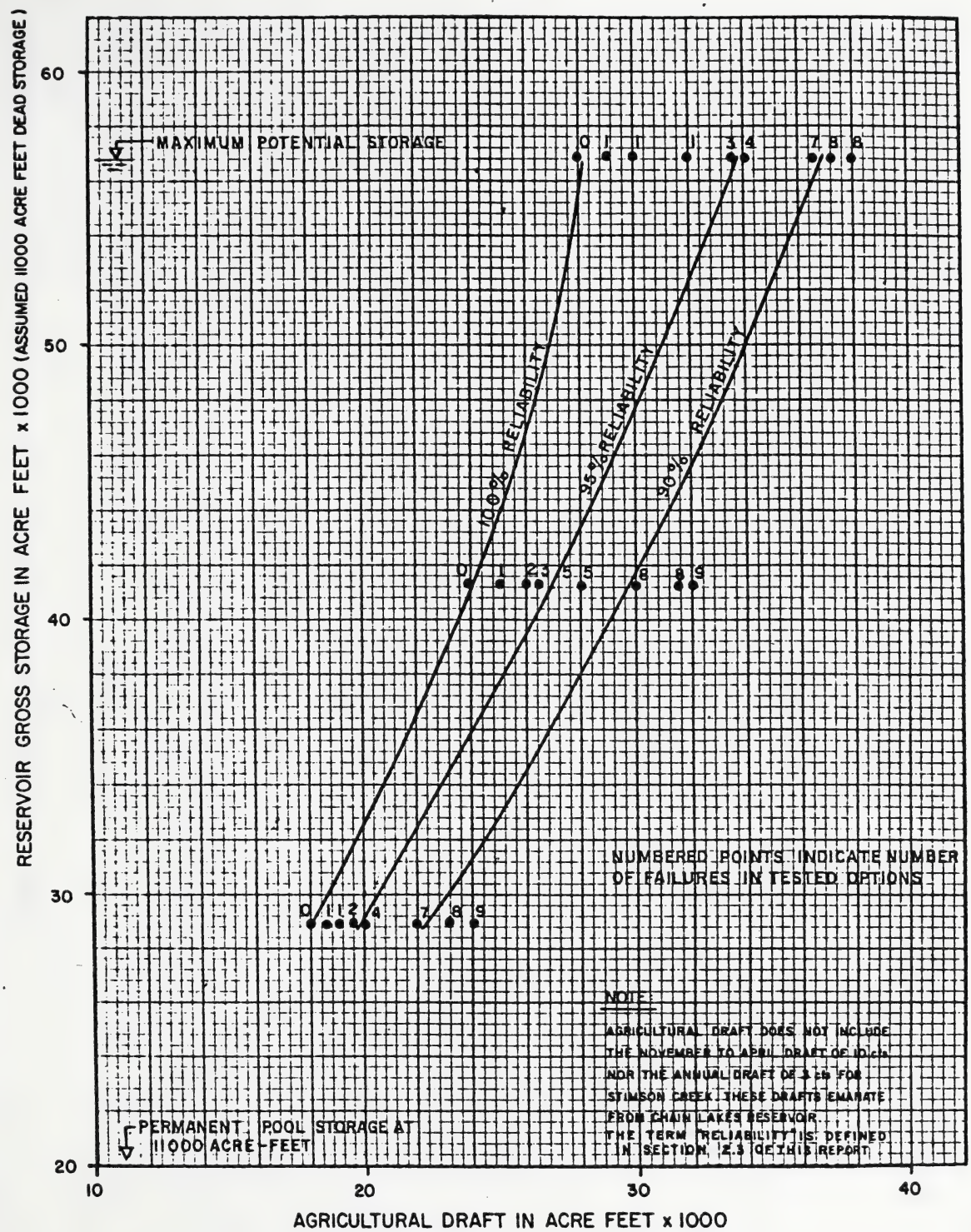

RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 11000 ACRE FEET DEAD STORAGE)
AGRICULTURAL DRAFT IN ACRE FEET x 1000
MAXIMUM POTENTIAL STORAGE
PERMANENT POOL STORAGE
300 600 900 cfs DIVERSION CAPACITY
100% RELIABILITY
95% RELIABILITY
90% RELIABILITY
NUMBERED POINTS INDICATE NUMBER OF FAILURES IN TESTED OPTIONS
NOTE:
AGRICULTURAL DRAFT DOES NOT INCLUDE THE NOVEMBER TO APRIL DRAFT OF 10 c.f.s NOR THE ANNUAL DRAFT OF 3 cfs FOR STIMSON CREEK. THESE DRAFTS EMANATE FROM CHAIN LAKES RESERVOIR.
THE TERM "RELIABILITY" IS DEFINED IN SECTION 2.3 OF THIS REPORT

Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	STORAGE DRAFT CURVES ALTERNATIVE A2 : PINE COULEE RESERVOIR
SUBMITTED S.J. FIGLIUZZI P.ENG. DATE	DESIGNED P.STEVENS P.ENG. CHECKED	
APPROVED A.M.MUSTAPHA P.ENG. DATE	DRAWN CHECKED P. STEVENS P. ENG.	SCALE AS SHOWN DATE SEPT 1985 — FIGURE No. 9

MICROFILM DATE

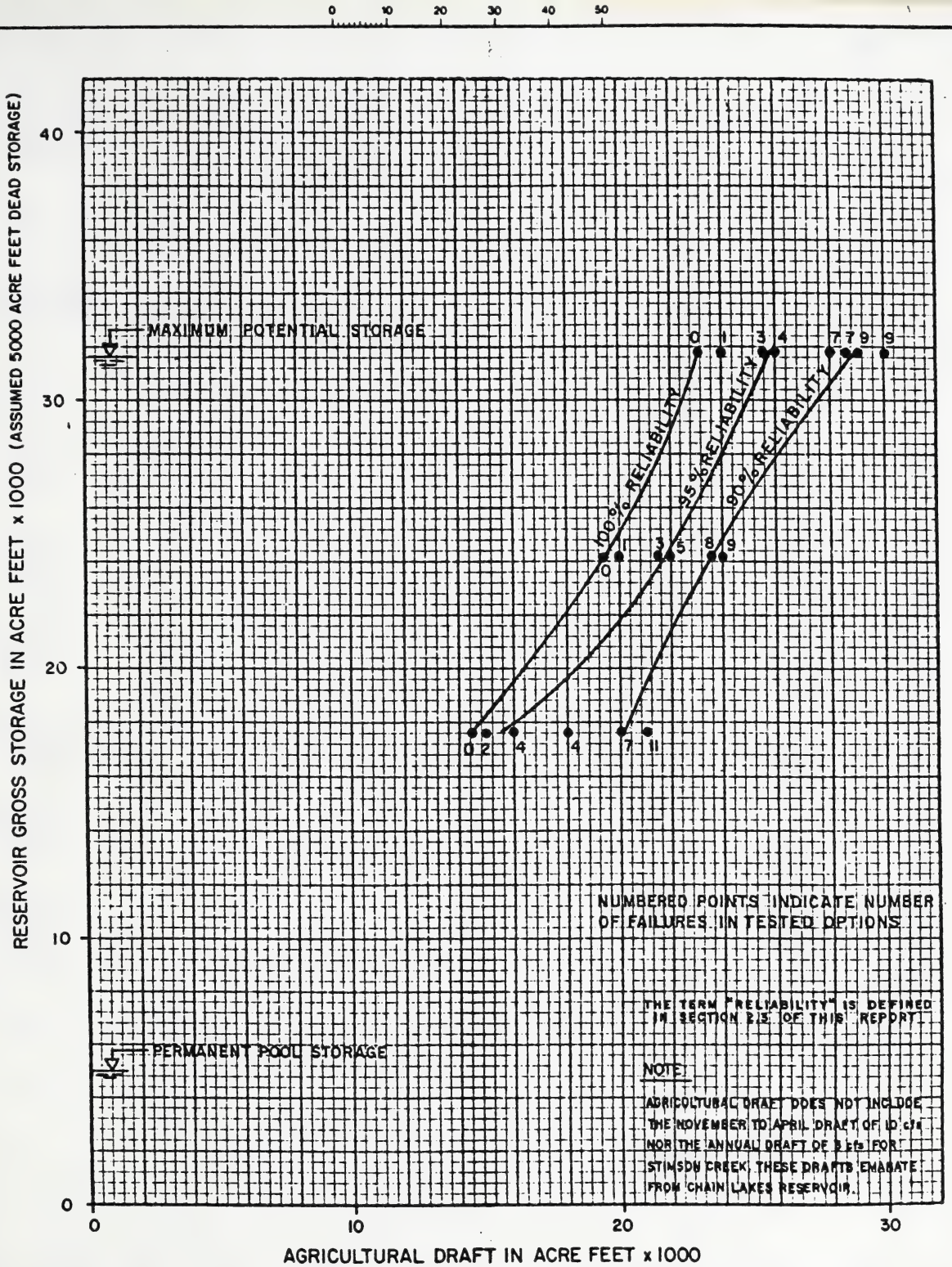
DRAWING No

FILE No


RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 11000 ACRE FEET DEAD STORAGE)
AGRICULTURAL DRAFT IN ACRE FEET x 1000
MAXIMUM POTENTIAL STORAGE
100% RELIABILITY
95% RELIABILITY
90% RELIABILITY
NUMBERED POINTS INDICATE NUMBER OF FAILURES IN TESTED OPTIONS
PERMANENT POOL STORAGE AT 11000 ACRE-FEET
NOTE:
AGRICULTURAL DRAFT DOES NOT INCLUDE THE NOVEMBER TO APRIL DRAFT OF 10 cfs NOR THE ANNUAL DRAFT OF 3 cfs FOR STIMSON CREEK. THESE DRAFTS EMANATE FROM CHAIN LAKES RESERVOIR.
THE TERM "RELIABILITY" IS DEFINED IN SECTION 2.3 OF THIS REPORT.

Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	STORAGE DRAFT CURVES ALTERNATIVE A3: PINE COULEE ONSTREAM RESERVOIR	
SUBMITTED B.V. FIGLIUZZI P. ENG. DATE	DESIGNED P. STEVENS P. ENG. CHECKED		
APPROVED A.M. MUSTAPHA P. ENG. DATE	DRAWN I. LUKNAR CHECKED P. STEVENS P. ENG.	SCALE AS SHOWN DATE SEPT. 1985	FIGURE No. 10

MICROFILM DATE
DRAWING No
FILE No


RESERVOIR GROSS STORAGE IN ACRE FEET x 1000 (ASSUMED 5000 ACRE FEET DEAD STORAGE)
AGRICULTURAL DRAFT IN ACRE FEET x 1000
MAXIMUM POTENTIAL STORAGE
PERMANENT POOL STORAGE
100% RELIABILITY
95% RELIABILITY
90% RELIABILITY
NUMBERED POINTS INDICATE NUMBER OF FAILURES IN TESTED OPTIONS
THE TERM "RELIABILITY" IS DEFINED IN SECTION 2.5 OF THIS REPORT
NOTE:
AGRICULTURAL DRAFT DOES NOT INCLUDE THE NOVEMBER TO APRIL DRAFT OF 10 cfs NOR THE ANNUAL DRAFT OF 3 cfs FOR STINSON CREEK. THESE DRAFTS EMANATE FROM CHAIN LAKES RESERVOIR.

Alberta Environment	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	STORAGE DRAFT CURVES ALTERNATIVE A4 : CLARESHOLM RESERVOIR
SUBMITTED S.J. FIGLIUZZI P. ENG. DATE	DESIGNED P. STEVENS P.ENG. CHECKED	
APPROVED A.M. MUSTAPHA P. ENG. DATE	DRAWN I. LUKNAR CHECKED P. STEVENS P. ENG	SCALE AS SHOWN DATE SEPT 1985
		FIGURE No. 11

MICROFILM DATE
DRAWING No
FILE No

Table 4.1: Reliability of Options

Option	Number of Failures in Month												Number of Years With at Least One Shortage in May to October Period	Basin Yield* acre-feet	Reliability %
	J	F	M	A	M	J	J	A	S	O	N	D			
100-A1		2	1										-	9600	100.0
95-A1	5	7	3				1	2	3	3	4	5	3	13100	95.8
90-A1	9	9	4				2	6	6	5	7	8	7	14600	90.3
100-A2a													-	26600	100.0
95-A2a								1	3	3			4	29100	94.4
90-A2a		1						4	7	6			7	31600	90.3
100-A2b													-	26600	100.0
95-A2b								1	3	2			4	29100	94.4
90-A2b		1						4	7	6			7	31600	90.3
100-A2c													-	26600	100.0
95-A2c								1	3	2			4	29100	94.4
90-A2c		1						4	7	6			7	31600	90.3
100-A3													-	31600	100.0
95-A3	3	3						1	3	4	1	2	4	37600	94.4
90-A3	4	4						4	4	6	1	3	7	40100	90.3
100-A4													-	26600	100.0
95-A4	1	1						2	3	4			4	29600	94.4
90-A4	3	3						3	6	6	1	1	7	32100	90.3

* Basin Yield = Reservoir Yield + Chain Lakes November-Through-April Yield

Table 4.2: Duration of Agricultural Demand Shortages

Scenario	Year of Occurrence	Duration, in months, starting in Month: May	June	July	Aug.	Sept.	Oct.	Reservoir Yield* (ac.-ft.)	Volume of Shortage (ac.-ft.)
100-A1								6000	
95-A1	1931					2		9500	546
	1936				3				1862
	1944				3				2393
90-A1	1919				3			11000	1328
	1931				3				2842
	1936			4					5824
	1937				2				1003
	1944			4					4704
	1961				2				1599
	1983						1		362
100-A2a								23000	
95-A2a	1931						1	25500	562
	1936					2			3199
	1937					1			976
	1944				3				3738
90-A2a	1919				3			28000	5827
	1931				3				4612
	1936				3				11353
	1937					2			2203
	1944				3				7936
	1961					1			1478
	1983					2			3265
100-A2b								23000	
95-A2b	1931						1	25500	562
	1936					2			3199
	1937					1			976
	1944				3				3738
90-A2b	1919				3			28000	5827
	1931				3				4612
	1936				3				7798
	1937					2			824
	1944				3				7936
	1961					1			1478
	1983					2			3265

* Reservoir yield refers to that yield produced by the downstream reservoir during the May through October period. It does not include the contribution by Chain Lakes Reservoir.

...Table 4.2 continued...

...Table 4.2 concluded...

Scenario	Year of Occurrence	Duration, in months, starting in Month: May	June	July	Aug.	Sept.	Oct.	Reservoir Yield* (ac.-ft.)	Volume of Shortage (ac.-ft.)
100-A2c								23000	
95-A2c	1931						1	25500	562
	1936					2			3199
	1937					1			976
	1944				3				3738
90-A2c	1919				3			28000	5827
	1931				3				4612
	1936				3				7798
	1937					2			824
	1944				3				7936
	1961					1			1478
	1973					2			3265
100-A3								28000	
95-A3	1919					2		34000	1528
	1936					2			4535
	1937				3				11889
	1944					1			282
90-A3	1919				3			36500	6200
	1931						1		1566
	1936				3				12353
	1937				3				13454
	1941				1				8701
	1944					2			4442
	1983						1		647
100-A4								23000	
95-A4	1919					2		26000	2500
	1931						1		248
	1937				3				3326
	1944				3				4048
90-A4	1919				3			28500	6596
	1931					2			2869
	1936					2			2567
	1937				3				5498
	1944				3				7068
	1961					1			1479
	1983						1		852

* Reservoir yield refers to that yield produced by the downstream reservoir during the May through October period. It does not include the contribution by Chain Lakes Reservoir.

Table 4.3: Duration of Winter Demand Shortages

Option	Year of Occurrence	Duration, in months, starting in Month: Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Volume of Shortage* (ac.-ft.)
100-A1	1937				2			482
	1945				1			489
95-A1	1919		3					1649
	1931	5						2655
	1936				1			529
	1936	5						2995
	1937	4						1841
	1944	5						2762
	1978				1			405
90-A1	1919	4						2235
	1931	5						2655
	1935	4						2255
	1936	5						2995
	1937	4						1873
	1944	5						2762
	1951			2				855
	1963			3				1264
	1977		3					1495
	1983	2						1132
100-A2	NO WINTER DEMAND SHORTAGES							
95-A2	NO WINTER DEMAND SHORTAGES							
90-A2	1978				1			333
100-A3	NO WINTER DEMAND SHORTAGES							
95-A3	1936	4						1346
	1938			2				317
	1944		3					902
90-A3	1931		3					545
	1936	4						1346
	1938			2				317
	1944		3					902
100-A4	NO WINTER DEMAND SHORTAGES							
95-A4	1945			2				492
90-A4	1936	4						618
	1945			2				492
	1978			2				586

* Willow Creek Winter requirements (November through April) total 3,600 acre-feet.

5. CONCLUSIONS

The hydrologic assessment of the several alternatives was based on the effects of the proposed reservoirs on the Willow Creek Basin monthly streamflow data sets. Due to the daily variability of flows, conclusions extrapolated from these results for time periods of less than one month should be undertaken with caution.

The results of the analyses reveal the following conclusions.

1. The larger the reservoir storage available, the greater the maximum annual draft. Hence, alternative A3 provides the greatest annual draft, followed by A2, A4, and A1. However, the efficiency of attaining the greater annual draft does not parallel the above statement. The ratio of maximum annual draft and maximum live storage provide a measure of this efficiency. These ratios for the 90% level of reliability are presented in Table 5.1. As can be seen, Alternative A4 offers greatest efficiency, followed by A2, A1, and A3.

Table 5.1: Efficiency of Attaining Maximum Annual Draft

Alternative	Guaranteed Annual Draft at 90% Reliability (GAD) (ac-ft)	Maximum Live Storage (MLS) (ac-ft)	GAD/MLS
A1	11000	11800	0.93
A2	28000	27490	1.02
A3	36500	45818	0.80
A4	28500	26731	1.07

2. Concerning Alternative A2, the reliability of the annual draft was shown to be very insensitive to the range of canal capacities tested in this assessment (as shown in Figure 3). Based on these results, it can be concluded that a canal capacity of 300 cfs would be adequate in supplying the Pine Coulee Offstream Reservoir. There is little or no gain in draft with a larger diversion canal capacity of 600 cfs or 900 cfs.

3. Under the proposed operation of reservoirs, Chain Lakes Reservoir would provide winter flows for municipal purposes only. The 10 cfs release requirement during the November through April period was always met by the existing reservoir. The 3 cfs requirement for Stimson Creek throughout the year was also always met.

   However, in the options involving downstream reservoirs, there were, on occasion, downstream flows of less than 10 cfs during the November through April period. These shortages were caused by a combination of low reservoir levels and the formation of surface ice in the reservoir during the winter season.

   Whether the alternative involved an onstream or offstream reservoir, flows of less than 10 cfs can still be expected downstream of the proposed reservoir due to the formation of channel ice.

4. The maximum reservoir draft shown in the storage-draft curves of Figures 8 through 11 were determined using a fixed distribution of demand, as presented in Table 3.2. Variation in the distribution of demands would have negligible effects on the computed yield. However, the effects of a significantly different distribution of demand on the resulting maximum reservoir draft should be verified using the procedures outlined in this report.

6. REFERENCES

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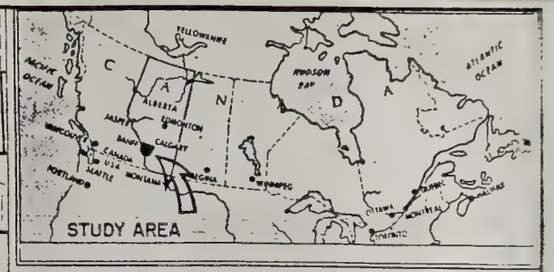
4. W.E.R. ENGINEERING LTD. (1981). South Saskatchewan River Basin Structures Inventory, Appendix 4, for Planning Division, Alberta Environment, Calgary, Alberta.



LEGEND

- MAJOR BASIN
- SUB - BASIN
- ▲ HYDROMETRIC STATION
- = POTENTIAL DAM SITE

LOCAL INFLOW DRAINAGE AREA

1. WSC 05AB028, WILLOW CREEK ABOVE CHAIN LAKES
2. LOCAL CHAIN LAKE INFLOW
3. LOCAL GA 2A INFLOW
4. GA 2 INFLOW
5. LOCAL GA1 INFLOW
6. LOCAL WSC 05AB021 INFLOW

SCALE 1:250 000

Miles 5 0 5 10 15 20 Miles

Kilometres 5 0 5 10 15 20 25 30 Kilometres

Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	WILLOW CREEK BASIN LOCAL INFLOW DRAINAGE BASINS
SUBMITTED DATE	DESIGNED P. STEVENS P.ENG. CHECKED	
APPROVED DATE	DRAWN S.B.N. CHECKED	SCALE 1:250 000 DATE SEPT. 1985

FIGURE No. A1

WSC STATION 05AB028: WILLOW CREEK ABOVE CHAIN LAKES

1912	3	3	12	45	92	115	108	74	30	29	15	9
1913	6	5	4	78	147	109	54	73	20	27	15	9
1914	6	5	4	34	63	58	17	5	4	26	14	9
1915	6	5	5	23	307	346	186	141	40	45	21	12
1916	8	6	15	49	99	358	125	167	82	77	31	17
1917	11	8	4	52	316	451	63	19	19	11	8	5
1918	3	3	3	21	65	40	8	18	5	12	8	5
1919	4	4	2	22	67	12	3	16	3	5	4	3
1920	2	2	5	57	302	151	77	17	6	5	4	3
1921	2	2	4	32	69	49	15	6	4	5	4	3
1922	2	2	2	32	122	63	20	6	3	3	3	2
1923	2	2	3	23	51	490	69	33	20	11	8	5
1924	3	3	4	46	95	145	37	79	11	10	7	5
1925	3	3	11	80	95	114	20	12	11	50	23	13
1926	8	6	6	43	31	100	38	9	61	149	50	26
1927	16	10	8	40	281	347	78	193	74	318	87	42
1928	25	14	38	70	154	225	121	33	26	27	15	9
1929	6	5	9	42	209	306	23	6	10	8	6	4
1930	3	3	7	69	105	91	30	8	7	6	5	3
1931	2	3	6	18	31	31	7	2	5	2	2	2
1932	1	2	3	22	102	330	19	10	9	8	6	4
1933	3	3	3	58	134	102	24	10	8	4	4	3
1934	2	2	6	38	113	50	13	2	5	5	4	3
1935	2	2	2	42	50	49	20	7	1	5	4	3
1936	2	2	3	39	27	25	3	1	1	0	1	1
1937	1	1	0	14	30	89	13	5	4	10	7	5
1938	3	3	4	33	201	97	40	5	2	5	4	3
1939	2	2	5	16	32	146	25	7	3	12	8	5
1940	4	4	3	32	79	40	13	4	9	34	17	10
1941	7	5	4	12	27	47	9	7	17	37	18	11
1942	7	6	3	30	298	442	130	110	94	48	22	13
1943	8	6	12	97	96	84	22	8	3	5	4	3
1944	2	2	2	15	28	20	7	4	2	2	2	2
1945	1	2	2	10	121	188	43	13	10	20	12	7
1946	5	4	9	22	52	153	31	15	19	29	15	9
1947	6	5	24	70	136	156	32	18	45	56	25	14
1948	9	7	4	90	401	294	70	41	10	10	7	5
1949	3	3	3	37	64	55	10	3	2	6	5	3
1950	2	3	4	35	82	51	14	11	2	4	4	3
1951	2	2	20	49	202	378	133	120	182	277	79	39
1952	23	13	19	105	105	142	58	31	17	10	7	5
1953	3	3	10	63	241	687	88	25	8	10	7	5
1954	3	3	7	45	178	119	27	37	29	49	22	13
1955	8	6	6	76	258	159	94	14	6	13	9	6
1956	4	4	8	27	111	41	52	16	15	7	5	4
1957	3	3	7	53	120	89	14	5	4	8	6	4
1958	3	3	4	67	150	107	106	26	11	8	6	4
1959	3	3	17	36	127	118	25	8	6	13	9	6
1960	4	4	19	20	117	55	9	8	2	3	3	2
1961	2	2	6	13	82	21	5	10	3	39	19	11
1962	7	6	12	60	64	40	7	3	3	4	4	3
1963	2	2	3	9	39	160	116	7	6	3	3	2
1964	2	2	2	20	195	106	21	6	5	8	6	4
1965	3	3	8	63	63	145	63	15	33	24	11	7
1966	4	4	13	26	75	126	44	27	11	9	8	4
1967	3	3	5	33	278	360	27	7	2	3	4	5
1968	5	3	8	16	44	84	26	20	40	46	20	16
1969	9	8	10	110	143	284	234	12	6	7	6	4
1970	0	2	4	19	128	183	39	5	5	6	5	3
1971	3	5	4	39	89	106	13	3	4	7	7	2
1972	2	3	20	73	189	90	31	50	35	29	18	10
1973	9	9	17	52	151	84	14	8	8	6	4	3
1974	2	2	7	63	241	142	19	18	15	14	8	7
1975	2	3	4	36	229	213	83	23	10	10	5	4
1976	4	3	10	37	78	45	16	154	20	11	7	6
1977	4	5	6	15	16	8	3	8	11	10	5	4
1978	3	3	12	46	150	116	65	25	18	12	11	7
1979	5	4	17	46	151	47	11	9	5	4	3	6
1980	4	2	3	43	65	93	11	12	18	15	14	9
1981	9	7	12	16	320	160	49	23	6	6	5	2
1982	0	0	0	20	30	93	21	3	4	7	5	3
1983	2	3	8	34	62	43	14	5	1	4	3	1

LOCAL INFLOW TO SITE #2A (CFS)

1912	2.	4.	63.	111.	144.	156.	191.	104.	60.	32.	16.	10.
1913	1.	6.	24.	191.	154.	122.	137.	47.	42.	26.	12.	7.
1914	1.	5.	24.	91.	65.	63.	49.	17.	13.	34.	17.	10.
1915	1.	6.	33.	71.	391.	604.	500.	191.	140.	43.	19.	21.
1916	0.	14.	69.	100.	149.	404.	227.	-56.	66.	42.	21.	19.
1917	0.	5.	35.	209.	614.	631.	181.	83.	48.	27.	19.	6.
1918	4.	8.	45.	54.	58.	55.	16.	0.	21.	14.	6.	1.
1919	2.	2.	4.	61.	43.	33.	1.	-8.	3.	10.	12.	4.
1920	4.	5.	53.	138.	537.	230.	57.	15.	11.	12.	9.	4.
1921	2.	6.	30.	87.	62.	42.	14.	3.	4.	11.	6.	3.
1922	1.	0.	3.	119.	168.	68.	40.	12.	3.	7.	5.	1.
1923	2.	0.	8.	48.	57.	781.	321.	138.	54.	24.	13.	8.
1924	3.	5.	38.	112.	135.	242.	98.	28.	23.	16.	10.	5.
1925	3.	4.	44.	135.	81.	167.	34.	14.	23.	37.	17.	23.
1926	1.	7.	19.	67.	42.	200.	164.	49.	259.	30.	15.	15.
1927	-3.	7.	52.	96.	507.	617.	186.	7.	339.	-17.	7.	19.
1928	-8.	8.	146.	205.	172.	367.	484.	169.	81.	35.	17.	10.
1929	1.	6.	41.	125.	300.	446.	88.	34.	21.	18.	11.	6.
1930	2.	37.	48.	124.	105.	94.	41.	10.	13.	14.	9.	5.
1931	3.	3.	20.	38.	38.	34.	10.	7.	8.	8.	6.	3.
1932	3.	3.	20.	57.	121.	497.	30.	18.	17.	14.	9.	4.
1933	3.	3.	20.	140.	157.	134.	39.	17.	16.	10.	7.	3.
1934	3.	3.	36.	94.	132.	60.	18.	6.	8.	10.	8.	3.
1935	3.	4.	16.	176.	61.	50.	18.	2.	1.	8.	6.	2.
1936	3.	3.	71.	144.	21.	20.	1.	0.	0.	1.	1.	0.
1937	1.	1.	8.	51.	39.	139.	23.	12.	4.	13.	9.	3.
1938	3.	4.	32.	120.	193.	95.	61.	18.	5.	10.	7.	3.
1939	3.	4.	52.	44.	14.	235.	62.	9.	6.	15.	10.	5.
1940	2.	3.	27.	78.	95.	40.	19.	8.	35.	19.	11.	6.
1941	1.	4.	18.	30.	20.	44.	17.	5.	23.	18.	9.	4.
1942	1.	4.	19.	80.	662.	514.	292.	93.	57.	42.	18.	13.
1943	1.	7.	88.	215.	122.	109.	48.	10.	7.	11.	8.	4.
1944	1.	1.	8.	60.	15.	30.	16.	7.	3.	7.	6.	2.
1945	1.	0.	18.	26.	135.	276.	89.	12.	22.	22.	9.	15.
1946	6.	7.	37.	45.	53.	161.	40.	10.	43.	22.	11.	8.
1947	7.	21.	77.	199.	166.	142.	57.	43.	94.	40.	26.	22.
1948	15.	12.	106.	318.	726.	475.	208.	82.	44.	21.	13.	3.
1949	2.	1.	16.	80.	56.	58.	26.	4.	3.	9.	10.	4.
1950	1.	6.	34.	75.	91.	77.	25.	9.	3.	9.	4.	4.
1951	3.	3.	188.	147.	299.	583.	273.	57.	241.	17.	27.	22.
1952	-3.	24.	112.	311.	175.	151.	114.	75.	43.	21.	14.	7.
1953	5.	9.	84.	143.	421.	1156.	265.	86.	55.	22.	18.	12.
1954	11.	17.	19.	119.	253.	173.	56.	40.	60.	50.	28.	13.
1955	4.	9.	17.	266.	488.	256.	242.	56.	38.	21.	7.	10.
1956	9.	5.	72.	98.	115.	64.	121.	23.	14.	14.	13.	6.
1957	2.	8.	43.	110.	159.	102.	33.	17.	16.	18.	15.	8.
1958	5.	5.	43.	252.	206.	133.	196.	73.	33.	14.	11.	11.
1959	6.	4.	99.	117.	178.	121.	55.	26.	31.	17.	18.	13.
1960	10.	17.	138.	74.	157.	75.	22.	12.	4.	6.	5.	4.
1961	4.	5.	14.	29.	73.	44.	10.	8.	8.	21.	11.	5.
1962	14.	23.	114.	231.	61.	47.	18.	7.	8.	7.	5.	3.
1963	3.	7.	13.	18.	24.	282.	312.	37.	17.	10.	7.	6.
1964	2.	2.	4.	54.	242.	163.	57.	16.	27.	14.	9.	4.
1965	2.	26.	9.	148.	58.	168.	170.	47.	56.	38.	18.	13.
1966	7.	6.	68.	65.	97.	260.	54.	31.	12.	14.	9.	5.
1967	2.	4.	96.	72.	470.	571.	162.	43.	13.	12.	10.	2.
1968	2.	4.	30.	21.	35.	67.	38.	25.	53.	54.	20.	8.
1969	7.	5.	91.	342.	237.	318.	469.	69.	34.	23.	18.	7.
1970	13.	14.	46.	91.	152.	172.	62.	18.	13.	16.	3.	5.
1971	27.	55.	64.	144.	56.	115.	26.	5.	7.	11.	5.	2.
1972	1.	5.	159.	207.	347.	168.	53.	55.	42.	19.	19.	9.
1973	15.	18.	47.	104.	216.	151.	44.	20.	16.	14.	9.	9.
1974	7.	10.	84.	123.	450.	242.	61.	38.	29.	19.	13.	9.
1975	9.	13.	42.	210.	332.	307.	139.	58.	29.	19.	12.	9.
1976	17.	6.	85.	86.	84.	47.	10.	80.	25.	16.	8.	8.
1977	11.	2.	20.	53.	22.	10.	0.	8.	5.	7.	1.	2.
1978	1.	-1.	93.	69.	231.	207.	106.	43.	40.	18.	12.	6.
1979	0.	7.	61.	150.	287.	114.	28.	26.	13.	10.	3.	1.
1980	0.	6.	21.	76.	63.	93.	9.	11.	13.	16.	5.	9.
1981	3.	7.	21.	17.	332.	292.	104.	52.	15.	15.	9.	2.
1982	2.	2.	13.	86.	29.	97.	45.	9.	14.	12.	9.	7.
1983	9.	8.	32.	30.	30.	24.	14.	-2.	-1.	5.	10.	8.

LOCAL INFLOW TO CLARESHOLM RESERVOIR (SITE #1) (CFS)

1912	0.	1.	8.	7.	10.	12.	24.	34.	0.	11.	6.	4.
1913	-1.	2.	1.	20.	16.	7.	11.	16.	2.	2.	4.	1.
1914	0.	1.	0.	5.	5.	3.	0.	-1.	0.	13.	7.	4.
1915	-1.	2.	0.	1.	43.	83.	83.	81.	2.	14.	7.	11.
1916	-2.	9.	0.	7.	10.	59.	30.	12.	1.	12.	10.	10.
1917	-3.	1.	1.	22.	48.	81.	10.	9.	-1.	12.	10.	1.
1918	0.	4.	3.	1.	6.	2.	-2.	-2.	0.	0.	-1.	-1.
1919	0.	0.	-2.	2.	6.	-1.	-1.	-1.	0.	0.	5.	1.
1920	1.	1.	3.	12.	50.	22.	4.	-2.	0.	3.	3.	0.
1921	0.	2.	1.	6.	6.	1.	-2.	-1.	0.	1.	1.	0.
1922	0.	-1.	-2.	8.	14.	3.	-1.	-2.	0.	1.	1.	-1.
1923	0.	-1.	-2.	0.	1.	80.	32.	30.	0.	10.	6.	2.
1924	1.	2.	2.	9.	12.	23.	3.	12.	-1.	1.	2.	0.
1925	0.	1.	4.	15.	8.	13.	-2.	-3.	-1.	10.	6.	13.
1926	-2.	2.	0.	5.	3.	14.	10.	2.	13.	2.	6.	8.
1927	-4.	4.	4.	6.	47.	84.	19.	40.	19.	-17.	3.	12.
1928	-7.	4.	35.	22.	16.	42.	76.	41.	2.	14.	8.	5.
1929	-1.	2.	4.	9.	28.	59.	2.	-1.	-1.	7.	5.	1.
1930	1.	26.	4.	12.	11.	6.	-1.	-2.	0.	4.	4.	1.
1931	1.	2.	0.	0.	3.	0.	-2.	-1.	0.	1.	2.	0.
1932	1.	1.	0.	2.	11.	69.	-2.	-3.	0.	3.	3.	1.
1933	0.	2.	0.	12.	14.	9.	-1.	-3.	0.	2.	2.	1.
1934	1.	2.	1.	7.	12.	1.	-2.	-1.	0.	2.	2.	1.
1935	1.	1.	0.	15.	4.	0.	-2.	-1.	0.	-2.	0.	-1.
1936	0.	1.	7.	11.	1.	-1.	-1.	0.	0.	0.	0.	0.
1937	1.	0.	-1.	1.	3.	9.	-1.	-2.	0.	-1.	2.	0.
1938	0.	1.	0.	8.	22.	7.	0.	-1.	0.	0.	2.	0.
1939	0.	1.	3.	0.	1.	22.	1.	-2.	0.	0.	1.	0.
1940	0.	1.	0.	5.	8.	1.	-2.	-1.	0.	-9.	-1.	-1.
1941	-1.	1.	0.	1.	1.	0.	-2.	-1.	0.	-13.	-2.	-2.
1942	-1.	0.	0.	4.	59.	83.	43.	42.	5.	15.	8.	6.
1943	-2.	3.	13.	25.	12.	7.	-1.	-2.	0.	1.	2.	0.
1944	-1.	-1.	-1.	2.	2.	0.	1.	-2.	0.	0.	0.	-1.
1945	-1.	-1.	0.	0.	14.	30.	10.	1.	0.	-1.	0.	7.
1946	1.	3.	2.	1.	5.	16.	4.	1.	1.	0.	3.	2.
1947	2.	15.	13.	22.	16.	14.	0.	8.	4.	12.	13.	13.
1948	9.	7.	15.	37.	65.	59.	4.	4.	0.	9.	5.	0.
1949	0.	-1.	0.	4.	5.	1.	-1.	-2.	0.	-1.	3.	1.
1950	-1.	4.	0.	4.	7.	2.	-5.	-1.	0.	0.	0.	1.
1951	1.	0.	42.	12.	29.	85.	36.	30.	19.	-1.	18.	14.
1952	-2.	17.	20.	38.	13.	13.	7.	12.	0.	8.	5.	3.
1953	2.	5.	11.	14.	38.	201.	20.	1.	1.	9.	10.	6.
1954	7.	12.	0.	9.	25.	12.	-2.	1.	1.	19.	15.	5.
1955	0.	4.	0.	30.	42.	24.	38.	3.	0.	5.	1.	5.
1956	5.	1.	9.	7.	11.	0.	14.	-1.	-1.	2.	6.	2.
1957	0.	5.	3.	10.	13.	6.	-6.	-1.	0.	6.	7.	3.
1958	2.	2.	3.	26.	19.	11.	32.	5.	0.	2.	5.	4.
1959	4.	1.	16.	9.	15.	9.	-7.	-2.	-1.	1.	9.	6.
1960	5.	11.	26.	4.	13.	2.	-5.	-1.	0.	1.	1.	2.
1961	2.	2.	0.	1.	8.	0.	0.	-2.	0.	-14.	-2.	-2.
1962	8.	16.	20.	24.	5.	0.	0.	-1.	0.	0.	1.	1.
1963	1.	4.	-1.	0.	2.	28.	48.	-1.	0.	4.	2.	2.
1964	1.	1.	-1.	2.	24.	12.	4.	-1.	0.	2.	2.	0.
1965	0.	18.	-1.	14.	5.	15.	17.	-2.	1.	-1.	1.	3.
1966	-1.	0.	9.	4.	8.	23.	-4.	-2.	0.	5.	6.	1.
1967	0.	1.	12.	2.	20.	67.	-17.	-2.	-1.	0.	2.	-1.
1968	1.	1.	0.	-2.	2.	4.	0.	1.	2.	39.	14.	9.
1969	6.	5.	1.	42.	19.	45.	112.	5.	0.	8.	9.	2.
1970	5.	9.	3.	5.	15.	23.	5.	-2.	0.	5.	-1.	2.
1971	20.	42.	8.	12.	7.	9.	0.	-3.	0.	3.	1.	-2.
1972	0.	2.	31.	21.	29.	8.	-7.	16.	1.	16.	16.	6.
1973	12.	16.	6.	11.	23.	10.	-1.	0.	0.	3.	2.	4.
1974	3.	5.	12.	13.	47.	22.	1.	0.	1.	5.	4.	6.
1975	4.	8.	4.	18.	31.	33.	11.	4.	0.	6.	2.	3.
1976	13.	3.	11.	7.	9.	1.	1.	55.	0.	1.	1.	5.
1977	7.	1.	0.	1.	2.	-1.	-1.	0.	-1.	0.	-3.	-1.
1978	-1.	-2.	-16.	2.	46.	19.	15.	6.	4.	4.	7.	3.
1979	0.	5.	10.	17.	35.	12.	0.	1.	1.	2.	-1.	1.
1980	0.	3.	0.	9.	-1.	2.	0.	0.	-2.	-2.	2.	5.
1981	3.	7.	1.	1.	5.	33.	13.	7.	0.	0.	0.	-3.
1982	-1.	-1.	-2.	1.	5.	3.	3.	-2.	-2.	-1.	1.	1.
1983	5.	5.	0.	2.	1.	0.	-3.	-2.	0.	-2.	3.	2.

LOCAL INFLOW TO WSC STATION 05AB021 (CFS)

1912	0.	1.	3.	3.	4.	4.	7.	9.	1.	3.	2.	1.
1913	0.	1.	0.	7.	5.	3.	3.	5.	0.	1.	1.	1.
1914	0.	1.	0.	2.	2.	1.	0.	-1.	0.	4.	2.	1.
1915	0.	1.	1.	1.	14.	26.	26.	24.	2.	5.	3.	4.
1916	0.	3.	3.	3.	4.	19.	9.	4.	1.	4.	3.	3.
1917	0.	1.	1.	7.	19.	31.	5.	3.	0.	4.	3.	1.
1918	0.	1.	1.	1.	2.	0.	0.	-1.	0.	0.	0.	-1.
1919	0.	0.	0.	1.	1.	0.	0.	-1.	0.	0.	1.	0.
1920	0.	1.	2.	4.	17.	7.	2.	0.	0.	1.	1.	0.
1921	0.	1.	0.	2.	2.	0.	0.	-1.	0.	0.	0.	0.
1922	0.	0.	0.	3.	5.	1.	0.	-1.	0.	0.	0.	0.
1923	0.	0.	0.	1.	1.	38.	11.	9.	1.	3.	2.	1.
1924	0.	1.	1.	3.	4.	7.	2.	4.	0.	1.	1.	0.
1925	0.	0.	1.	5.	3.	4.	0.	0.	0.	3.	2.	4.
1926	0.	1.	0.	2.	1.	5.	4.	1.	4.	1.	2.	3.
1927	-1.	1.	2.	3.	16.	26.	6.	11.	5.	-3.	2.	4.
1928	-2.	2.	11.	7.	6.	13.	21.	11.	1.	4.	2.	1.
1929	0.	1.	1.	4.	9.	19.	1.	0.	0.	2.	1.	1.
1930	0.	7.	1.	4.	3.	2.	0.	-1.	0.	1.	1.	0.
1931	0.	0.	0.	1.	1.	0.	0.	-1.	0.	1.	1.	0.
1932	0.	0.	0.	1.	4.	21.	0.	0.	0.	1.	1.	0.
1933	0.	0.	0.	5.	5.	3.	0.	0.	0.	1.	1.	0.
1934	0.	0.	1.	2.	4.	1.	0.	-1.	0.	1.	1.	0.
1935	0.	0.	0.	5.	2.	1.	0.	-1.	0.	0.	0.	0.
1936	0.	0.	3.	4.	1.	0.	0.	0.	0.	0.	0.	0.
1937	0.	0.	0.	1.	1.	3.	0.	-1.	0.	0.	0.	0.
1938	0.	0.	1.	3.	7.	2.	1.	-1.	0.	0.	0.	0.
1939	0.	0.	2.	1.	1.	7.	0.	-1.	0.	0.	1.	0.
1940	0.	0.	0.	2.	3.	0.	0.	-1.	0.	-2.	0.	0.
1941	0.	0.	0.	0.	1.	0.	0.	-1.	0.	-3.	0.	0.
1942	0.	0.	0.	2.	20.	26.	13.	11.	1.	5.	3.	2.
1943	0.	1.	4.	9.	3.	2.	0.	-1.	0.	1.	1.	0.
1944	0.	0.	0.	1.	0.	0.	0.	-1.	0.	0.	0.	0.
1945	0.	0.	0.	0.	4.	9.	3.	0.	0.	-1.	0.	2.
1946	1.	1.	1.	1.	1.	5.	1.	0.	0.	1.	1.	1.
1947	1.	4.	4.	7.	5.	5.	1.	3.	1.	3.	4.	4.
1948	3.	2.	5.	13.	24.	19.	3.	2.	0.	3.	2.	0.
1949	0.	0.	0.	2.	2.	1.	0.	-1.	0.	0.	1.	0.
1950	0.	1.	1.	2.	3.	1.	-1.	0.	0.	0.	0.	0.
1951	0.	0.	13.	5.	9.	26.	11.	9.	6.	1.	5.	4.
1952	-1.	5.	7.	13.	5.	5.	3.	4.	0.	2.	2.	1.
1953	1.	2.	4.	5.	13.	62.	7.	1.	0.	3.	3.	2.
1954	2.	3.	0.	3.	8.	5.	-1.	1.	1.	5.	4.	2.
1955	0.	1.	0.	10.	15.	8.	11.	1.	0.	2.	0.	1.
1956	1.	1.	3.	2.	4.	1.	4.	0.	0.	1.	1.	1.
1957	0.	1.	1.	3.	5.	2.	-2.	0.	0.	2.	2.	1.
1958	1.	1.	1.	9.	6.	3.	10.	2.	0.	1.	1.	2.
1959	1.	1.	6.	3.	5.	3.	-2.	0.	0.	1.	2.	2.
1960	2.	3.	9.	1.	5.	1.	-1.	0.	0.	0.	0.	0.
1961	1.	1.	0.	0.	2.	0.	0.	-1.	0.	-4.	0.	0.
1962	2.	4.	6.	8.	2.	0.	0.	0.	0.	0.	0.	0.
1963	0.	1.	0.	0.	1.	9.	14.	0.	0.	1.	1.	1.
1964	0.	0.	0.	1.	8.	4.	1.	0.	0.	0.	1.	0.
1965	0.	5.	0.	5.	2.	5.	6.	0.	1.	0.	1.	1.
1966	0.	1.	3.	1.	3.	7.	0.	-1.	0.	1.	1.	1.
1967	0.	1.	4.	2.	15.	25.	-3.	0.	0.	0.	1.	0.
1968	1.	1.	1.	0.	1.	1.	0.	1.	1.	10.	4.	2.
1969	2.	1.	4.	15.	7.	14.	31.	2.	0.	2.	3.	1.
1970	2.	2.	1.	2.	5.	6.	1.	-1.	0.	2.	0.	0.
1971	5.	11.	2.	4.	2.	3.	0.	-1.	0.	1.	1.	0.
1972	0.	1.	11.	8.	10.	4.	-1.	5.	1.	4.	4.	2.
1973	4.	4.	2.	3.	6.	3.	0.	0.	0.	1.	1.	1.
1974	1.	2.	4.	4.	13.	7.	0.	1.	0.	1.	1.	1.
1975	1.	2.	1.	6.	11.	11.	4.	1.	0.	2.	1.	1.
1976	3.	1.	4.	2.	2.	0.	0.	15.	0.	1.	0.	1.
1977	2.	0.	0.	1.	0.	0.	0.	0.	0.	0.	-1.	0.
1978	0.	0.	4.	2.	13.	6.	5.	2.	2.	1.	2.	1.
1979	0.	1.	4.	6.	11.	3.	0.	0.	1.	1.	0.	0.
1980	0.	1.	1.	2.	0.	1.	0.	0.	0.	0.	0.	2.
1981	1.	2.	0.	0.	3.	10.	4.	2.	0.	0.	0.	-1.
1982	-1.	-1.	0.	1.	1.	1.	1.	0.	0.	0.	0.	1.
1983	1.	1.	0.	1.	1.	0.	-1.	-1.	0.	0.	1.	1.

WSC STATION 05AB028, WILLOW CREEK NEAR CLARESHOLM (CFS)

1912	6	10	90	177	261	299	344	227	96	77	41	25
1913	7	15	30	310	334	253	213	145	66	58	34	19
1914	7	13	29	140	140	129	68	21	17	80	42	25
1915	7	15	41	103	784	1103	829	454	195	113	54	50
1916	7	33	102	168	274	876	408	134	159	142	68	51
1917	9	16	43	301	1050	1261	276	122	71	56	42	14
1918	8	17	54	81	135	100	23	15	27	27	13	4
1919	6	6	5	90	120	45	3	6	6	15	22	8
1920	7	9	66	222	945	427	146	32	17	21	17	7
1921	4	11	37	133	144	96	28	7	8	17	11	6
1922	3	1	4	171	322	140	62	15	6	11	9	2
1923	4	1	10	77	118	1491	455	217	78	49	30	17
1924	7	12	47	179	255	434	146	128	35	30	21	11
1925	6	9	63	246	195	310	55	25	35	104	51	54
1926	8	17	26	122	79	332	226	64	349	191	77	54
1927	9	23	70	152	888	1119	301	259	451	296	105	80
1928	10	29	242	319	363	673	726	262	114	82	43	26
1929	7	15	57	189	569	864	120	41	32	36	24	13
1930	6	74	63	220	232	201	73	16	20	25	19	9
1931	6	8	27	60	75	67	15	7	13	12	11	5
1932	5	6	24	85	246	954	50	27	27	26	19	9
1933	6	8	24	226	323	258	65	26	25	17	14	7
1934	6	7	46	148	271	117	30	6	13	18	15	7
1935	6	7	18	249	121	104	38	7	2	11	10	4
1936	5	6	88	209	51	45	3	1	1	1	2	1
1937	3	2	7	70	75	250	36	14	8	23	18	8
1938	6	8	39	173	440	209	107	22	7	15	13	6
1939	5	7	65	64	49	426	92	13	9	29	21	11
1940	6	9	32	122	192	84	31	10	46	45	29	16
1941	7	11	23	44	50	95	25	10	42	42	27	14
1942	7	11	23	121	1085	1109	496	264	163	114	54	35
1943	8	18	123	363	241	210	72	16	10	18	15	7
1944	2	2	9	81	46	52	25	8	5	9	8	3
1945	1	1	20	37	284	522	151	27	33	41	21	31
1946	13	15	51	72	115	348	79	27	66	54	32	21
1947	17	46	125	312	358	330	94	74	149	116	71	54
1948	37	29	138	481	1276	885	299	135	57	44	28	9
1949	5	4	19	131	132	120	36	4	5	14	19	8
1950	2	14	41	121	190	136	35	19	5	13	8	8
1951	6	5	277	224	561	1115	471	223	463	307	134	82
1952	19	60	166	491	310	324	190	127	63	42	29	17
1953	11	20	115	235	744	2193	396	119	67	45	39	26
1954	23	36	27	186	482	323	84	82	95	127	72	34
1955	13	21	24	400	840	466	399	77	46	43	18	23
1956	19	12	97	140	250	110	199	40	30	24	25	13
1957	5	17	56	185	308	207	42	22	20	35	31	17
1958	11	12	53	372	397	263	357	111	46	26	24	22
1959	14	10	146	173	339	262	75	34	38	34	39	28
1960	21	36	203	104	304	139	26	19	6	10	9	8
1961	9	10	21	44	171	67	15	16	11	46	30	15
1962	31	50	160	338	137	91	26	9	11	11	10	7
1963	6	14	15	28	68	497	508	45	24	18	13	11
1964	5	5	5	80	488	296	86	22	33	24	18	8
1965	5	52	16	241	133	346	266	63	95	64	33	25
1966	11	12	98	100	189	433	99	58	24	29	24	11
1967	5	9	124	116	842	1079	179	51	15	16	18	7
1968	10	10	41	38	85	163	66	48	99	150	59	35
1969	24	20	125	535	424	685	871	92	42	41	37	15
1970	21	28	56	122	310	396	110	21	18	29	7	10
1971	55	113	81	209	160	242	40	4	11	22	14	2
1972	3	11	235	325	601	284	81	130	81	70	58	28
1973	41	48	75	176	409	257	59	29	25	24	16	17
1974	13	19	111	213	776	430	84	61	46	40	26	23
1975	16	26	52	283	629	589	249	90	41	38	21	18
1976	37	14	116	138	179	97	28	312	47	30	16	20
1977	24	8	27	73	41	17	2	16	15	17	2	5
1978	3	0	126	127	454	361	198	78	68	36	32	17
1979	5	17	97	229	501	182	40	37	20	17	5	8
1980	4	12	27	135	132	195	20	24	30	30	21	25
1981	16	23	35	35	689	511	175	86	22	22	14	0
1982	0	0	11	112	67	202	72	10	16	18	15	12
1983	17	17	41	69	97	69	25	0	0	7	17	12

APPENDIX B

LISTINGS OF COMPUTER PROGRAMS FOR THE ASSESSMENT OF RESERVOIR SCHEMES

	Listing
Offstream Reservoir Model	B1
Onstream Reservoir Model	B2

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CCC     PROGRAM 'RS.OFFRES' COMPUTES WATER ALLOCATION GIVEN
CCC     INFLOWS, DEMANDS AND AN OFFSTREAM RESERVOIR.
CCC     VARIABLES AND THEIR DEFINITIONS FOLLOW.
CCC     TO RUN: RUN S.OFFRES 1=RESDATA 2=INFLOWS 3=EVAP 4=PRECIP
CCC     5=LOCAL INFLOWS 6=5-DAY %'S 7=OUTPUT 8=S/S FLOWS 9=RES.ELS 10=6
CCC
CCC     VARIABLE  UNIT     DEFINITION
CCC
C       ARELAS      ACRES    PREVIOUS MONTH'S SURFACE AREA
C       AREPRE(12)ACRES    PRESENT SURFACE AREA OF RESERVOIR
C       DELTA       AC-FT    STOMAX - STOPRE
C       DEMAND(12)  CFS      WATER DEMAND EACH MONTH
C       DEMAND(12)AC-FT    90% WATER DEMAND EACH MONTH
C       DEM28       AC-FT    WATER DEMAND FOR 28-DAY FEBRUARY
C       DICE(12)    FT       DEPTH OF ICE IN RESERVOIR
C       DIVCAP      CFS      DIVERSION CAPACITY TO RESERVOIR
C       DIVCPS(6) AC-FT    MAX DIV. VOL. TO RES., 6-DAY PERIODS
C       DSFLOW(12) CFS      TOTAL FLOW D/S OF RESERVOIR
C       D28         AC-FT    DEMAND IN FEBRUARY FOR LEAP YEAR
C       D288        AC-FT    90% DEMAND IN FEB. FOR LEAP YEAR
C       ELPRE(12)   FT       PRESENT WATER ELEVATION OF RESERVOIR
C       EVAP(12)    MM       EVAPORATION, EACH MONTH
C       GOME        AC-FT    VOL. OF INFLOW RELEASED FOR RIP + DEM
C       IC          -        CHECK ON LEAP YEAR
C       INFIN       -        LAST MONTH EACH YEAR DIV.CANAL OPERATES
C       INSTA       -        FIRST MONTH EACH YEAR DIV.CANAL OPERATES
C       IY          -        YEAR OF RES. INFLOW DATA
C       IYY         -        YEAR OF PCENT DATA
C       KDEM(12)    -        COUNTER, #  OF MONTHS 90% OF DEMAND SHORT
C       KDIV(12)    -        COUNTER, #MONTHS DIV. DEPENDANT ON CANAL CAP
C       KRIP(12)    -        COUNTER, #  OF MONTHS 90% OF RIPARIAN SHORT
C       KSPI(12)    -        COUNTER, NUMBER OF MONTHS SPILL RES'D
C       LY          -        =1 IF LEAP YEAR, OTHERWISE =0
C       NDAYS(12)   -        NUMBER OF DAYS EACH MONTH
C       NEL         -        NO. OF ELEVATION-AREA-VOLUME POINTS
C       NET(12)     AC-FT    PRECIP - EVAP  EACH MONTH
C       OUTDEM(12)AC-FT    ACTUAL DEMAND RELEASED EACH MONTH
C       OUTDIV(12)AC-FT    DIVERSION INTO RESERVOIR EACH MONTH
C       OUTRIP(12)AC-FT    ACTUAL RIPARIAN RELEASED EACH MONTH
C       OUTSPI(12)AC-FT    SPILL FROM RESERVOIR EACH MONTH
C       PCENT(6,12) -        FRACTION OF MONTHLY VOLUME IN 6-DAY PERIODS
C       PRECIP(12) MM        PRECIPITATION, EACH MONTH
C       QIN(12)     CFS      INFLOW EACH MONTH
C       QINR(12)    CFS      LOCAL INFLOW TO RESERVOIR EACH MONTH
C       QP          AC-FT    QIN + OUTSPI
C       Q1          AC-FT    QIN - RIPAR; INFLOW - RIPARIAN
C       Q2          AC-FT    Q1 - DEMAND
C       Q4          AC-FT    STOLIV + Q1  DIFF OF LIVE STORAGE, NET RIP
C       Q5          AC-FT    STOLIV + Q2  DIFF OF LIVE STORAGE, NET DEM
C       Q6          AC-FT    ACTUAL VOL.DIVERTED TO RES.(VOLDIV OR DELTA)
C       RESARE(20)ACRES    RESERVOIR SURFACE AREA POINTS
C       RESEL(20)   FT       RESERVOIR ELEVATION POINTS
C       RESVOL(20)AC-FT    RESERVOIR GROSS VOLUME POINTS
C       RIPAR(12)   CFS      RIPARIAN FLOW EACH MONTH
C       RIPAR9(12)AC-FT    90% RIPARIAN  EACH MONTH
C       RIP28       AC-FT    RIPARIAN FLOW FOR 28-DAY FEBRUARY
C       R29         AC-FT    RIPARIAN FLOW FOR FEB. IN A LEAP YEAR
C       R299        AC-FT    90% RIPARIAN FOR FEB. IN A LEAP YEAR
C       SPILL       AC-FT    SPILL FROM RESERVOIR
C       STOICE(12)AC-FT    STORAGE TAKEN UP BY ICE
C       STOLAS      AC-FT    PREVIOUS MONTH'S STORAGE VOLUME
C       STOLIV      AC-FT    STOMAX - STOPRE  LIVE STORAGE AVAILABLE
C       STOMAX      AC-FT    MAXIMUM GROSS STORAGE (DEAD + LIVE)
C       STOMIN      AC-FT    DEAD STORAGE
C       STOPRE(12)AC-FT    PRESENT RESERVOIR GROSS VOLUME
C       STOSTA      AC-FT    STARTING RESERVOIR VOLUME
C       SURPLU(12)AC-FT    EXCESS INFLOW THAT CANNOT BE STORED
C       VOLDIV      AC-FT    MAX.DIV.VOL.AVAIL.DUE TO DIV.CANAL CAP.
C       VOLIN       AC-FT    AVAIL VOL. FOR DIVERSION TO RES.
C       WNET        AC-FT    ACCUMULATED PRECIP-EVAP IN WINTER MONTHS
C       YEAR        -        YEAR BEING ANALYZED
C
        INTEGER YEAR
        REAL NET
        DIMENSION RESEL(20),RESARE(20),RESVOL(20),RIPAR(12),DEMAND(12)
        DIMENSION NDAYS(12),KRIP(12),KDEM(12),OUTRIP(12),OUTDEM(12)
        DIMENSION SURPLU(12),OUTSPI(12),STOPRE(12),QIN(12),OUTDIV(12)
        DIMENSION NET(12),ELPRE(12),AREPRE(12),EVAP(12),PRECIP(12)
        DIMENSION KSPI(12),DICE(12),QINR(12),STOICE(12),DSFLOW(12)
        DIMENSION RIPAR9(12),DEMAND(12),KDIV(12),PCENT(6,12)
        DIMENSION DIVCPS(6)
        DATA NDAYS(1)/31/,NDAYS(2)/28/,NDAYS(3)/31/,NDAYS(4)/30/
        DATA NDAYS(5)/31/,NDAYS(6)/30/,NDAYS(7)/31/,NDAYS(8)/31/
        DATA NDAYS(9)/30/,NDAYS(10)/31/,NDAYS(11)/30/,NDAYS(12)/31/
C
        READ(1,100)STOSTA, DIVCAP, STOMAX,STOMIN,NEL
  100   FORMAT( 4F10.0,I4)
        DO 10 I=1,NEL
        READ(1,100) RESEL(I), RESARE(I), RESVOL(I)
   10   CONTINUE
        READ(6,105) INSTA,INFIN
  105   FORMAT(2I4)
        DO 11 I=1,12
        READ(1,100) RIPAR(I),DEMAND(I),DICE(I)
        RIPAR(I)=RIPAR(I)*1.9835*NDAYS(I)
        RIPAR9(I)=0.9*RIPAR(I)
        DEMAND(I)=DEMAND(I)*1.9835*NDAYS(I)
        DEMAND(I)=0.9*DEMAND(I)
        KDIV(I)=0
        KRIP(I)=0
        KDEM(I)=0
        KSPI(I)=0
   11   CONTINUE
C
        RIP28=RIPAR(2)
        DEM28=DEMAND(2)
        R29=RIPAR(2)*29/28
        R299=0.9*R29
        D29=DEMAND(2)*29/28
        D299=0.9*D29
        STOLAS=STOSTA
C
        CALL LININT(ELPRE(1),ARELAS,STOLAS,NEL,RESEL,RESARE,RESVOL)
        WRITE(7,200)STOMAX,STOSTA,DIVCAP
  200   FORMAT( 'RESERVOIR CAPACITY = ',F8.0,' AC-FT',/,'STARTING RESERVOI
       *R VOLUME = ',F8.0,' AC-FT',/,'DIVERSION CANAL CAPACITY = ',F8.0,'
       *CFS',/)
        WRITE(7,201)
  201   FORMAT( 'MONTH GROSS ADD.ICE     U/S     LOCAL  PRECIP   RIPAR  DEM
       *AND  DIVERS SURPLUS  SPILL')
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      CCC    INFLOWS, DEMANDS AND AN DOWNSTREAM RESERVOIR.
      CCC    VARIABLES AND THEIR DEFINITIONS FOLLOW.
      CCC    TO RUN:  RUN C ONRES 1=RESDATA 2=INFLOWS 3=EVAP 4=PRECIP
      CCC             5=LOCAL INFLOWS 7=OUTPUT 8=D/S FLOWS 9=RES ELS 10=10S
      CCC
      CCC    VARIABLE  UNIT     DEFINITION
      CCC
      C      ARELAS     ACRES    PREVIOUS MONTH'S SURFACE AREA
      C      ARSPRE(12)ACRES     PRESENT SURFACE AREA OF RESERVOIR
      C      DELTA      AC-FT    STOMAX - STOICE - STOPRE
      C      DEMAND(12) CFS      WATER DEMAND EACH MONTH
      C      DEMAN2(12) CFS      WATER DEMAND, NORTH END, EACH MONTH
      C      DEMAN9(12)AC-FT     90% WATER DEMAND EACH MONTH
      C      DEMA29(12)AC-FT     90% WATER DEMAND, NORTH END, EACH MONTH
      C      DEM28      AC-FT    WATER DEMAND FOR 28-DAY FEBRUARY
      C      DE228      AC-FT    WATER DEMAND, NORTH END, FOR 28-DAY FEB
      C      DE29       AC-FT    DEMAND, NORTH END, FOR 29-DAY FEB.
      C      DE299      AC-FT    90% DEMAND, NORTH END, FOR 29-DAY FEB.
      C      D29        AC-FT    DEMAND FOR 29-DAY FEB.
      C      D299       AC-FT    90% DEMAND FOR 29-DAY FEB.
      C      DICE(12)    FT      DEPTH OF ICE IN RESERVOIR
      C      DSFLOW(12) CFS      TOTAL FLOW D/S OF RESERVOIR
      C      ELPRE(12)   FT      PRESENT WATER ELEVATION OF RESERVOIR
      C      EVAP(12)    MM      EVAPORATION, EACH MONTH
      C      IC           -      CHECK ON LEAP YEAR
      C      IY           -      YEAR OF RES. INFLOW DATA
      C      KDEM(12)     -      COUNTER, NUMBER OF MONTHS DEMAND SHORTAGE
      C      KDE2(12)     -      COUNTER, NUMBER OF MONTHS NORTH DEMAND SHORT
      C      KRIP(12)     -      COUNTER, NUMBER OF MONTHS RIPARIAN SHORT
      C      KSPI(12)     -      COUNTER, NUMBER OF MONTHS SPILL REQ'D
      C      LY           -      =1 IF LEAP YEAR, OTHERWISE =0
      C      NDAYS(12)    -      NUMBER OF DAYS EACH MONTH
      C      NEL          -      NO. OF ELEVATION-AREA-VOLUME POINTS
      C      NET(12)    AC-FT    PRECIP - EVAP  EACH MONTH
      C      OUTDEM(12)AC-FT     ACTUAL DEMAND RELEASED EACH MONTH
      C      OUTDE2(12)AC-FT     ACTUAL DEMAND RELEASED NORTH END EACH MONTH
      C      OUTRIP(12)AC-FT     ACTUAL RIPARIAN RELEASED EACH MONTH
      C      OUTSPI(12)AC-FT     SPILL FROM RESERVOIR EACH MONTH
      C      PRECIP(12) MM       PRECIPITATION, EACH MONTH
      C      QIN(12)     CFS     INFLOW EACH MONTH
      C      QINR(12)    CFS     LOCAL INFLOW TO RESERVOIR EACH MONTH
      C      QTIN(12)   AC-FT    QIN + QINR, TOTAL INFLOW TO RESERVOIR
      C      Q1         AC-FT    SPILL - RIPAR, SPILL - RIPARIAN
      C      Q2         AC-FT    Q1 - RIPARIAN - DEMAND
      C      Q3         AC-FT    Q2 - RIPARIAN - DEMAND - DEMAN2
      C      Q4         AC-FT    STOLIV + Q1  DIFF OF LIVE STORAGE, SPILL-RIP
      C      Q5         AC-FT    STOLIV + Q2  DIFF OF LIVE STORAGE, SPILL-DEM
      C      Q7         AC-FT    STOLIV + Q3, DIFF OF LIVE STORAGE, SPILL-DE2
      C      RESARE(20)ACRES     RESERVOIR SURFACE AREA POINTS
      C      RESEL(20)   FT      RESERVOIR ELEVATION POINTS
      C      RESVOL(20)AC-FT     RESERVOIR GROSS VOLUME POINTS
      C      RIPAR(12)   CFS     RIPARIAN FLOW EACH MONTH
      C      RIPAR9(12)AC-FT     90% RIPARIAN EACH MONTH
      C      RIP28      AC-FT    RIPARIAN FLOW FOR 28-DAY FEBRUARY
      C      R29        AC-FT    RIPARIAN FOR 29-DAY FEB.
      C      R299       AC-FT    90% RIPARIAN FOR 29-DAY FEB.
      C      SPILL      AC-FT    SPILL FROM RESERVOIR
      C      STOICE(12)AC-FT     STORAGE TAKEN UP BY ICE
      C      STOLAS     AC-FT    PREVIOUS MONTH'S STORAGE VOLUME
      C      STOLIV     AC-FT    STOMAX - STOPRE  LIVE STORAGE AVAILABLE
      C      STOMAX     AC-FT    MAXIMUM GROSS STORAGE (DEAD + LIVE)
      C      STOMIN     AC-FT    DEAD STORAGE
      C      STOPRE(12)AC-FT     PRESENT RESERVOIR GROSS VOLUME
      C      STOSTA     AC-FT    STARTING RESERVOIR VOLUME
      C      SURPLU(12)AC-FT     EXCESS INFLOW THAT CANNOT BE STORED
      C      WNET       AC-FT    ACCUMULATED PRECIP-EVAP IN WINTER MONTHS
      C      YEAR         -      YEAR BEING ANALYZED
      C
            INTEGER YEAR
            REAL NET
            DIMENSION RESEL(20),RESARE(20),RESVOL(20),RIPAR(12),DEMAND(12)
            DIMENSION NDAYS(12),KRIP(12),KDEM(12),OUTRIP(12),OUTDEM(12)
            DIMENSION SURPLU(12),OUTSPI(12),STOPRE(12),QIN(12),QTIN(12)
            DIMENSION NET(12),ELPRE(12),ARSPRE(12),EVAP(12),PRECIP(12)
            DIMENSION KSPI(12),DICE(12),QINR(12),STOICE(12),DEMAN2(12)
            DIMENSION OUTDE2(12),KDE2(12),DSFLOW(12),DEMAN9(12),RIPAR9(12)
            DIMENSION DEMA29(12)
            DATA NDAYS(1)/31/,NDAYS(2)/28/,NDAYS(3)/31/,NDAYS(4)/30/
            DATA NDAYS(5)/31/,NDAYS(6)/30/,NDAYS(7)/31/,NDAYS(8)/31/
            DATA NDAYS(9)/30/,NDAYS(10)/31/,NDAYS(11)/30/,NDAYS(12)/31/
      C
            READ(1,100)STOSTA,STOMAX,STOMIN,NEL
       100  FORMAT( 3F10.0,I4)
            DO 10 I=1,NEL
            READ(1,100) RESEL(I), RESARE(I), RESVOL(I)
        10  CONTINUE
            DO 11 I=1,12
            READ(1,104) RIPAR(I),DEMAND(I),DEMAN2(I),DICE(I)
       104  FORMAT( 4F10.0)
            RIPAR(I)=RIPAR(I)*1.9835*NDAYS(I)
            RIPAR9(I)=0.9*RIPAR(I)
            DEMAND(I)=DEMAND(I)*1.9835*NDAYS(I)
            DEMAN9(I)=0.9*DEMAND(I)
            DEMAN2(I)=DEMAN2(I)*1.9835*NDAYS(I)
            DEMA29(I)=0.9*DEMAN2(I)
            KRIP(I)=0
            KDEM(I)=0
            KDE2(I)=0
            KSPI(I)=0
        11  CONTINUE
      C
            RIP28=RIPAR(2)
            DEM28=DEMAND(2)
            DE228=DEMAN2(2)
            R29=RIPAR(2)*29/28
            R299=0.9*R29
            D29=DEMAND(2)*29/28
            D299=0.9*D29
            DE29=DEMAN2(2)*29/28
            DE299=0.9*DE29
            STOLAS=STOSTA
      C
            CALL LININT(ELPRE(1),ARELAS,STOLAS,NEL,RESEL,RESARE,RESVOL)
            WRITE(7,200)STOMAX,STOSTA
       200  FORMAT(' RESERVOIR CAPACITY = ',F8.0,' AC-FT',/,'STARTING RESERVOI
           +R VOLUME = ',F8.0,' AC-FT',/)
            WRITE(7,201)
       201  FORMAT(' 'MONTH GROSS  ADD.ICE    U/S    LOCAL   PRECIP    RIPAR  SOU
           +TH   NORTH  SURPLUS  SPILL')
```

```
341           GOTO 60
342       CC
343       CC      SHORTAGE OF INFLOW, RELEASE FROM RES. TO MEET RIP.
344       CC
345         30    IF(STOPRE(L).GT.STOMIN) GOTO 32
346               OUTRIP(L)=QIN(L)
347               IF(L.EQ.2.AND.LY.EQ.1) GOTO 33
348               IF(RIPAR(L).NE.0.AND.OUTRIP(L).LT.RIPARS(L)) KRIP(L)=KRIP(L)+1
349               IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.DEMAND(L))KDEM(L)=KDEM(L)+1
350               GOTO 34
351         33    IF(RIPAR(L).NE.0.AND.OUTRIP(L).LT.R200) KRIP(L)=KRIP(L)+1
352               IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.D200) KDEM(L)=KDEM(L)+1
353         34    SURPLU(L)=01-DEMAND(L)
354               GOTO 60
355         32    STOLIV=STOPRE(L)-STOMIN
356               04=STOLIV+01
357               IF(04.LT.0.0) GOTO 51
358               STOPRE(L)=STOPRE(L)+01
359               OUTRIP(L)=RIPAR(L)
360               02=0.0-DEMAND(L)
361       CC
362       CC      SHORTAGE OF INFLOW, RELEASE FROM RESERVOIR TO MEET DEMAND
363       CC
364         31    STOLIV=STOPRE(L)-STOMIN
365               05=STOLIV+02
366               IF(05.LT.0.0) GOTO 52
367               STOPRE(L)=STOPRE(L)+02
368               OUTDEM(L)=DEMAND(L)
369               GOTO 60
370       CC
371       CC      EXCESS INFLOW TO BE PASSED
372       CC
373         40    SURPLU(L)=02
374               STOPRE(L)=STOMAX-STOICE(L)
375               GOTO 60
376         51    OUTRIP(L)=RIPAR(L)+04
377               IF(OUTRIP(L).LT.0.) OUTRIP(L)=0.
378               STOPRE(L)=STOMIN
379               OUTDEM(L)=0.0
380               SURPLU(L)=04-DEMAND(L)
381               IF(L.EQ.2.AND.LY.EQ.1) GOTO 53
382               IF(RIPAR(L).NE.0.AND.OUTRIP(L).LT.RIPARS(L)) KRIP(L)=KRIP(L)+1
383               IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.DEMAND(L))KDEM(L)=KDEM(L)+1
384               GOTO 55
385         53    IF(RIPAR(L).NE.0.AND.OUTRIP(L).LT.R200) KRIP(L)=KRIP(L)+1
386               IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.D200)KDEM(L)=KDEM(L)+1
387         55    GOTO 60
388       C
389         52    OUTDEM(L)=DEMAND(L)+05
390               IF(OUTDEM(L).LT.0.) OUTDEM(L)=0.
391               STOPRE(L)=STOMIN
392               SURPLU(L)=05
393               IF(L.EQ.2.AND.LY.EQ.1) GOTO 56
394               IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.DEMAND(L))KDEM(L)=KDEM(L)+1
395               GOTO 60
396         56    IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.D200) KDEM(L)=KDEM(L)+1
397       CC
398       CC      DETERMINE PRESENT RES ELEV, SURFACE AREA, VOLUME
399       CC
400         60    STOLAS=STOPRE(L)+STOICE(L)
401               DSFLOW(L)=OUTRIP(L)+OUTDEM(L)+SURPLU(L)
402               IF(DSFLOW(L).LT.0.0) DSFLOW(L)=0.
403               DSFLOW(L)=DSFLOW(L)/(1.9835*NDAYS(L))
404       C
405               CALL LININT(ELPRE(L),AREPRE(L),STOLAS,NEL,RESEL,RESARE,RESVOL)
406               WRITE(7,205)L,STOPRE(L),STOICE(L),QIN(L),QINR(L),NET(L),
407              * OUTRIP(L),OUTDEM(L),OUTDIV(L),SURPLU(L),OUTSPI(L)
408           205 FORMAT(14,10F8.0)
409       C
410               ARELAS=AREPRE(L)
411           21  CONTINUE
412               WRITE(8,101) YEAR,(DSFLOW(J),J=1,12)
413               WRITE(9,200) YEAR,(ELPRE(J),J=1,12)
414           205 FORMAT(15,12F8.1)
415           20  CONTINUE
416               WRITE(7,216)
417           216 FORMAT( /,/,'NUMBER OF TIMES:')
418               WRITE(7,218)
419           218 FORMAT( '  IN      SPILLWAY  RIPARIAN    DEMAND DIV.DEPEND')
420               WRITE(7,220)
421           220 FORMAT( ' MONTH      USED      NOT MET   NOT MET ON CANAL CAP.')
422               DO 59 K=1,12
423               WRITE(7,221) K,KSPI(K),KRIP(K),KDEM(K),KDIV(K)
424           221 FORMAT( I4,4I10)
425            59 CONTINUE
426           500 STOP
427               END
428               SUBROUTINE LININT(EL,ARE,STO,NEL,RESEL,RESARE,RESVOL)
429               DIMENSION RESEL(20),RESARE(20),RESVOL(20)
430       C
431               DO 2 I=1,NEL
432               X1=RESVOL(I)
433               X2=RESVOL(I+1)
434               IF(STO.GE.X1.AND.STO.LE.X2) GOTO 70
435             2 CONTINUE
436       CC
437       CC      INPUT DATA TOO LARGE - EXTRAPOLATE ABOVE RANGE
438               WRITE(7,300) STO
439           300 FORMAT( 'STORAGE VOLUME GREATER THAN STOMAX:',F10.0)
440       CC
441       CC      CALCULATE RES AREA
442       CC
443            70 Y1=RESARE(I)
444               Y2=RESARE(I+1)
445               SLOPE=(Y2-Y1)/(X2-X1)
446               ARE=(STO-X2)*SLOPE+Y2
447       CC
448       CC      CALCULATE RES ELEVATION
449       CC
450               Y1=RESEL(I)
451               Y2=RESEL(I+1)
452               SLOPE=(Y2-Y1)/(X2-X1)
453               EL=(STO-X2)*SLOPE+Y2
454               RETURN
455               END
End of file
```

```
      IF(L.EQ.2.AND.LY.EQ.1) GOTO 94
      IF(RIPAR(L).NE.0.AND.OUTRIP(L).LT.RIPAR(L)) KRIP(L)=KRIP(L)+1
      GOTO 95
   94 IF(RIPAR(L).NE.0.AND.OUTRIP(L).LT.9200) KRIP(L)=KRIP(L)+1
   95 STOPRE(L)=STOMIN
      OUTRIP(L)=RIPAR(L)*04
      OUTSPI(L)=OUTSPI(L)+OUTRIP(L)
      IF(L.EQ.2.AND.LY.EQ.1) GOTO 96
      IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.DEMAND(L)) KDEM(L)=KDEM(L)+1
      IF(DEMAN2(L).NE.0.AND.OUTDE2(L).LT.DEMA20(L)) KDE2(L)=KDE2(L)+1
      GOTO 97
   96 IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.9200) KDEM(L)=KDEM(L)+1
      IF(DEMAN2(L).NE.0.AND.OUTDE2(L).LT.9E200) KDE2(L)=KDE2(L)+1
   97 OUTDEM(L)=0.0
      OUTDE2(L)=0.0
      SURPLU(L)=04-DEMAND(L)-DEMAN2(L)
      GOTO 99
   93 IF(L.EQ.2.AND.LY.EQ.1) GOTO 56
      IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.DEMAND(L)) KDEM(L)=KDEM(L)+1
      IF(DEMAN2(L).NE.0.AND.OUTDE2(L).LT.DEMA20(L)) KDE2(L)=KDE2(L)+1
      GOTO 99
   56 IF(DEMAND(L).NE.0.AND.OUTDEM(L).LT.D200) KDEM(L)=KDEM(L)+1
      IF(DEMAN2(L).NE.0.AND.OUTDE2(L).LT.9E200) KDE2(L)=KDE2(L)+1
   99 STOPRE(L)=STOMIN
      OUTDEM(L)=DEMAND(L)*05
      OUTSPI(L)=OUTSPI(L)+OUTDEM(L)
      OUTDE2(L)=0.0
      SURPLU(L)=05-DEMAN2(L)
      GOTO 99
   53 IF(L.EQ.2.AND.LY.EQ.1) GOTO 61
      IF(DEMAN2(L).NE.0.AND.OUTDE2(L).LT.DEMA20(L)) KDE2(L)=KDE2(L)+1
      GOTO 62
   61 IF(DEMAN2(L).NE.0.AND.OUTDE2(L).LT.9E200) KDE2(L)=KDE2(L)+1
   62 STOPRE(L)=STOMIN
      OUTDE2(L)=DEMAN2(L)*07
      OUTSPI(L)=OUTSPI(L)+OUTDE2(L)
      SURPLU(L)=07-DEMAN2(L)
CC
CC    DETERMINE PRESENT RES ELEV, SURFACE AREA, VOLUME
CC
   99 STOLAS=STOPRE(L)+STOICE(L)
      DSFLOW(L)=(OUTSPI(L)-OUTDE2(L))/(11.8835*NDAYS(L))
C
      CALL LININT(ELPRE(L),AREPRE(L),STOLAS,NEL,RESEL,RESARE,RESVOL)
      WRITE(7,205)L,STOPRE(L),STOICE(L),OIN(L),OINR(L),NET(L),
     * OUTRIP(L),OUTDEM(L),OUTDE2(L),SURPLU(L),OUTSPI(L)
  205 FORMAT(I4,10F8.0)
C
      ARELAS=AREPRE(L)
   31 CONTINUE
      WRITE(8,101) YEAR,(DSFLOW(J),J=1,12)
      WRITE(8,208) YEAR,(ELPRE(J),J=1,12)
  208 FORMAT(I5,12F8.1)
   30 CONTINUE
      WRITE(7,218)
  218 FORMAT( /,/,'NUMBER OF TIMES:')
      WRITE(7,219)
  219 FORMAT( '  IN      SPILLWAY  RIPARIAN    DEMAND  N.DEMAND')
      WRITE(7,220)
  220 FORMAT( ' MONTH      USED      NOT MET  NOT MET    NOT MET')
      DO 60 K=1,12
      WRITE(7,221) K,KSPI(K),KRIP(K),KDEM(K),KDE2(K)
  221 FORMAT( I4,4I10)
   60 CONTINUE
  600 STOP
      END
      SUBROUTINE LININT(EL,ARE,STO,NEL,RESEL,RESARE,RESVOL)
      DIMENSION RESEL(20),RESARE(20),RESVOL(20)
C
      DO 2 I=1,NEL
      X1=RESVOL(I)
      X2=RESVOL(I+1)
      IF(STO.GE.X1.AND.STO.LE.X2) GOTO 70
    2 CONTINUE
CC
CC    INPUT DATA TOO LARGE - EXTRAPOLATE ABOVE RANGE
      WRITE(7,300) STO
  300 FORMAT( 'STORAGE VOLUME GREATER THAN STOMAX:',F10.0)
CC
CC    CALCULATE RES AREA
CC
   70 Y1=RESARE(I)
      Y2=RESARE(I+1)
      SLOPE=(Y2-Y1)/(X2-X1)
      ARE=(STO-X2)*SLOPE+Y2
CC
CC    CALCULATE RES ELEVATION
CC
      Y1=RESEL(I)
      Y2=RESEL(I+1)
      SLOPE=(Y2-Y1)/(X2-X1)
      EL=(STO-X2)*SLOPE+Y2
      RETURN
      END
End of file
```

APPENDIX C

Stations Used to Produce 5-Day Volumetric
Distribution of Streamflows ..... Table C1

TABLE C1: STATIONS USED TO PRODUCE 5-DAY VOLUMETRIC DISTRIBUTION OF STREAMFLOWS

YEAR	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1912	4	4	4	4	1	1	1	1	1	1	4	4
1913	4	4	4	4	1	1	1	1	1	1	4	4
1914	4	4	4	1	1	1	1	1	1	1	4	4
1915	4	4	4	1	1	1	1	1	1	1	1	1
1916	1	1	1	1	1	1	1	1	1	1	1	1
1917	1	1	1	1	1	1	1	1	1	1	1	1
1918	1	1	1	1	1	1	1	1	1	1	1	1
1919	1	1	1	1	1	1	1	1	1	1	1	1
1920	1	1	1	1	1	1	1	1	1	1	1	1
1921	1	1	1	1	1	1	1	1	1	1	1	1
1922	1	1	1	1	1	1	1	1	1	1	1	1
1923	1	1	1	1	1	1	1	1	1	1	4	4
1924	3	3	1	3	2	2	2	2	2	2	3	3
1925	3	3	2	2	2	2	2	2	2	2	3	3
1926	3	3	2	2	2	2	2	2	2	2	3	3
1927	3	3	2	2	2	2	2	2	2	2	3	3
1928	3	3	2	2	2	2	2	2	2	2	3	3
1929	3	3	2	2	2	2	2	2	2	2	3	3
1930	3	2	2	2	2	2	2	2	2	2	3	3
1931	3	3	2	2	3	3	3	4	4	4	4	4
1932	4	4	4	4	4	4	4	4	4	4	6	6
1933	6	6	6	6	6	6	6	6	6	6	6	6
1934	5	5	5	5	5	5	5	5	5	5	5	5
1935	5	5	5	2	2	2	2	2	2	2	5	5
1936	5	5	2	2	2	2	2	2	2	2	5	5
1937	5	5	2	2	2	2	2	2	2	2	5	5
1938	5	5	2	2	2	2	2	2	2	2	5	5
1939	5	5	2	2	2	2	2	2	2	2	5	5
1940	5	5	2	2	2	2	2	2	2	2	5	5
1941	5	5	2	2	2	2	2	2	2	2	5	5
1942	5	5	1	1	1	1	1	1	1	1	5	5
1943	5	5	1	1	1	1	1	1	1	1	5	5
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0

0 = WSC STATION 05AB021, WILLOW CREEK NEAR CLARESHOLM
1 = WSC STATION 05AB002, WILLOW CREEK NEAR NOLAN
2 = WSC STATION 05AB015, WILLOW CREEK NEAR GRANUM
3 = WSC STATION 05BL008, HIGHWOOD RIVER NEAR ALDERSYDE
4 = WSC STATION 05BJ001, ELBOW RIVER BELOW GLENMORE DAM
5 = WSC STATION 05BJ005, ELBOW RIVER ABOVE GLENMORE DAM
6 = WSC STATION 05AE002, LEE CREEK AT CARDSTON

N.L.C. - B.N.C.
3 3286 07292357 2